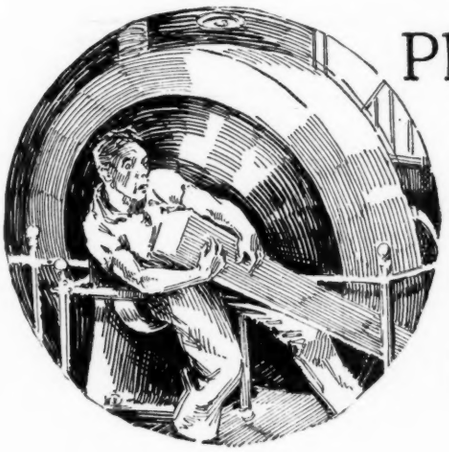
POWER

Volume 52 New York, August 24, 1920 *Number* 8



PREVARICATING PETE

by

RUFUS T STROHM

ULYSSES, crafty, brave and bold, could draw the longbow, so we're told; but here's our old friend, Peter Stiles, who has him beaten sixty miles. By that we don't intend to call Old Pete a liar—not at all! Let's use diplomacy and say his fancies sort of run away, till finally they get so far that Pete can't tell just where they are.

For instance, Peter swears that he prevented a catastrophe when he was working at the mill of Brown and Son, beyond the hill. It seems the main belt broke one day and let the engine run away; but Peter chanced to stand close by, and quick as you could wink an eye he grabbed a stick of six-by-four that stood outside the open door, applied it to the flywheel rim with resolution stern and grim, and braked the engine with his beam till other hands shut off the steam.

And once a piece of shafting fell endwise and hit the boiler shell and punched a disk out, sharp and clean as anything you've ever seen. The steam, escaping in a blast, reduced the pressure mighty fast, and Peter saw he'd have to stop that roaring leak or close the shop. So, with a judgment truly fine he whittled out a plug of pine and drove it in that hissing gap, and stopped the jet of steam, kerslap! Moreover, as the soft wood swelled, the pressure was more firmly held.

Munchausen, in his early day, produced some whoppers, so they say, but Peter has that Baron chap eliminated from the map. He grabs the outer robe of truth and stretches it until, forsooth, you hear the fibers tear apart and see the seams and stitches start; and while he boldly falsifies, he looks you squarely in the eyes, insulting your intelligence, because he thinks you lack the sense to see his highly colored junk is bosh and blarney, bull and bunk.

One man outbids Pete Stiles for fame, and Ananias is his name.

Ten-Thousand Horsepower Station for Operating Shipyard

By JULIUS G. BERGER*

Combined 5,000-Kva. Turbo-Alternator and 4,500-Hp. Air-Compressor Plant—New Plant Built Around Old Station While Latter Was Kept in Operation—Steam Header 590 Ft. Long and Main Air Line 2,315 Ft. Long has Butt-Welded Connections—Acceptance Test Data and Performance Are Given.

THE Merchant Shipbuilding Corporation, acting as agent for the United States Shipping Board, Emergency Fleet Corporation, acquired, in the summer of 1917, a tract of land immediately to the northeast of the borough of Bristol, Pa., now known as Harriman, on which has been erected one of three large Government shipyards for building steel merchant ships. The tract contains about 265 acres and includes the property formerly occupied by the Standard Cast-Iron Pipe and Foundry Company. Bristol is twenty-three miles northeast of Philadelphia, on the deep tidewater section of the Delaware River at a point which is the terminus of the Delaware & Lehigh Canal and on the main line of the Pennsylvania Railroad.

At the northeast end of the shipyard property along the river front, which has a southwesterly direction, there are twelve shipways, each having a north-and-south direction and arranged at an angle of about 45 deg. to the river front. To the southwest of the course of shipways and down the stream therefrom there is a 1,135-ft. fitting-out wharf, which will accommodate three ships simultaneously. The steel storage yards, fabricating shops, storehouses, power house and other industrial buildings are grouped in an approximately parallel direction to the river front at the head of the shipways and of the fitting-out wharf.

The shipyard is so designed and proportioned as to be able to construct thirty-six 8,800-ton fabricated steel merchant ships per year. There are used in the building of ships 53 shops and other industrial buildings which vary in size, shape, construction and location, according to the special need; there are 12 buildings used in the fabrication of steel, 9 for fitting out ships, 18 for power generation and distribution and for storing or pumping oil, water and sewage, and 14 for office and administration and general utility purposes. For electric power, pumping, etc., there are 1 power house, 14 distributing and substations and 2 oil and sewage pumphouses.

The power house is in Yard No. 3, near the center of power distribution, close to the river, where there is an abundance of water for condenser purposes, and along the wharf where coal may be unloaded from either boat or railway as de-

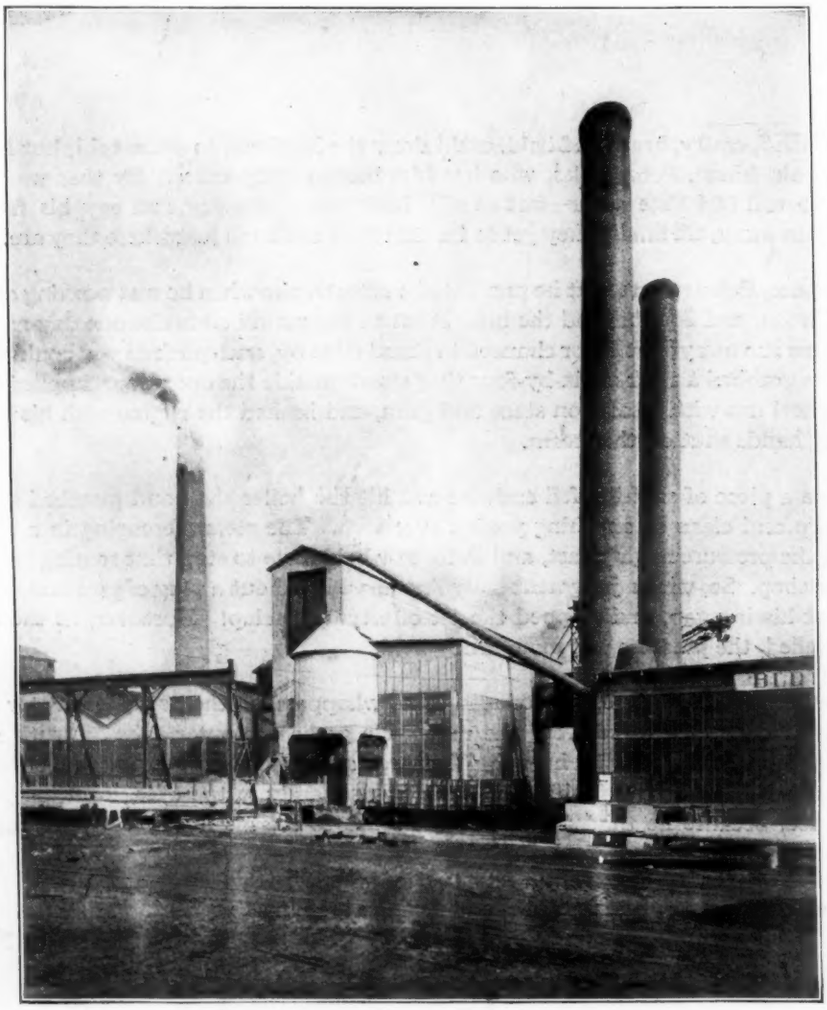


FIG. 1. GENERAL VIEW OF REBUILT POWER PLANT

*Manager (Newark, N. J.) office L. K. Comstock Co., New York City; formerly chief engineer Wm. Gordon Corp., New York.

sired. The Standard Cast-Iron Pipe and Foundry Company, former owners of the property occupied by the Merchant Shipbuilding Corporation, operated a direct-current power plant for their supply. In this plant there were four 200-hp. horizontal return-tubular boilers; one 9-in. x 5-in. x 10-in. boiler-feed pump; one closed feed-water heater, one 300-kw., 250-volt direct-current generator, direct connected to a horizontal cross-compound engine; two 150-kw. 250-volt direct-current generators, each directly connected to a horizontal cross-compound engine, and one 100-kw. 250-volt, direct-current generator, directly connected to a vertical high-speed engine.

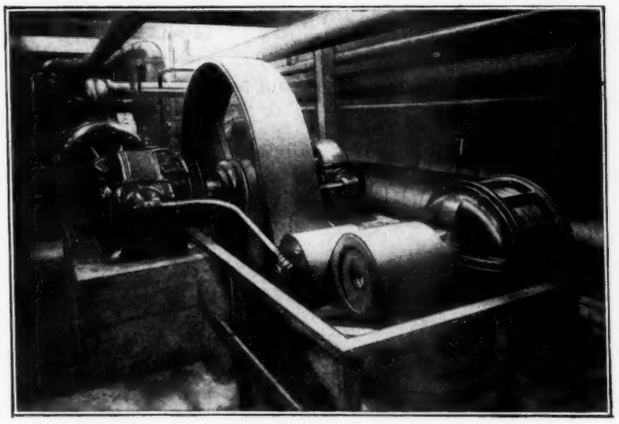


FIG. 2. MOTOR-DRIVEN VACUUM PUMP

The original intention was to remove this power house, but owing to shortage of material and the fact that a rotary-converter substation of about 600-kw. capacity would have had to be erected to supply direct current in that particular vicinity of what was to be the shipyard, it was decided to retain the old power-house building and construct a new alternating-current plant adjacent to it. When the location of the buildings was determined upon, lack of space necessitated the building of the new power house around three sides of the plant, as shown on the general plan, Fig. 7.

Prior to the war it had been customary to determine the equipment required for an industrial development on which the size of the power house was based. However, the stress of war times made it necessary to determine the power house before the other requirements were barely known. This resulted in taking data from existing shipyards and reducing them to a unit basis and multiplying by the sizes of the various shops in this yard. In this manner the power, air and steam requirements were obtained. The air is of particular interest, as it was determined by measuring under actual operating conditions the amount used at the yard of the Chester Shipbuilding Co., Ltd., Chester, Pa., and increased to meet anticipated high production.

Apparatus obtainable, rather than the best combination of sizes for the load conditions, determined the selection; besides, the manufacturers who could make best deliveries received prime considerations. Fortunately, favorable deliveries were obtained on a selection of apparatus from reliable manufacturers in their respective lines. Deliveries, of course, were based on A-1 priority, and in the case of the turbo-alternators a requisitioning order issued by Admiral Capps made it possible to take units destined for other purposes.

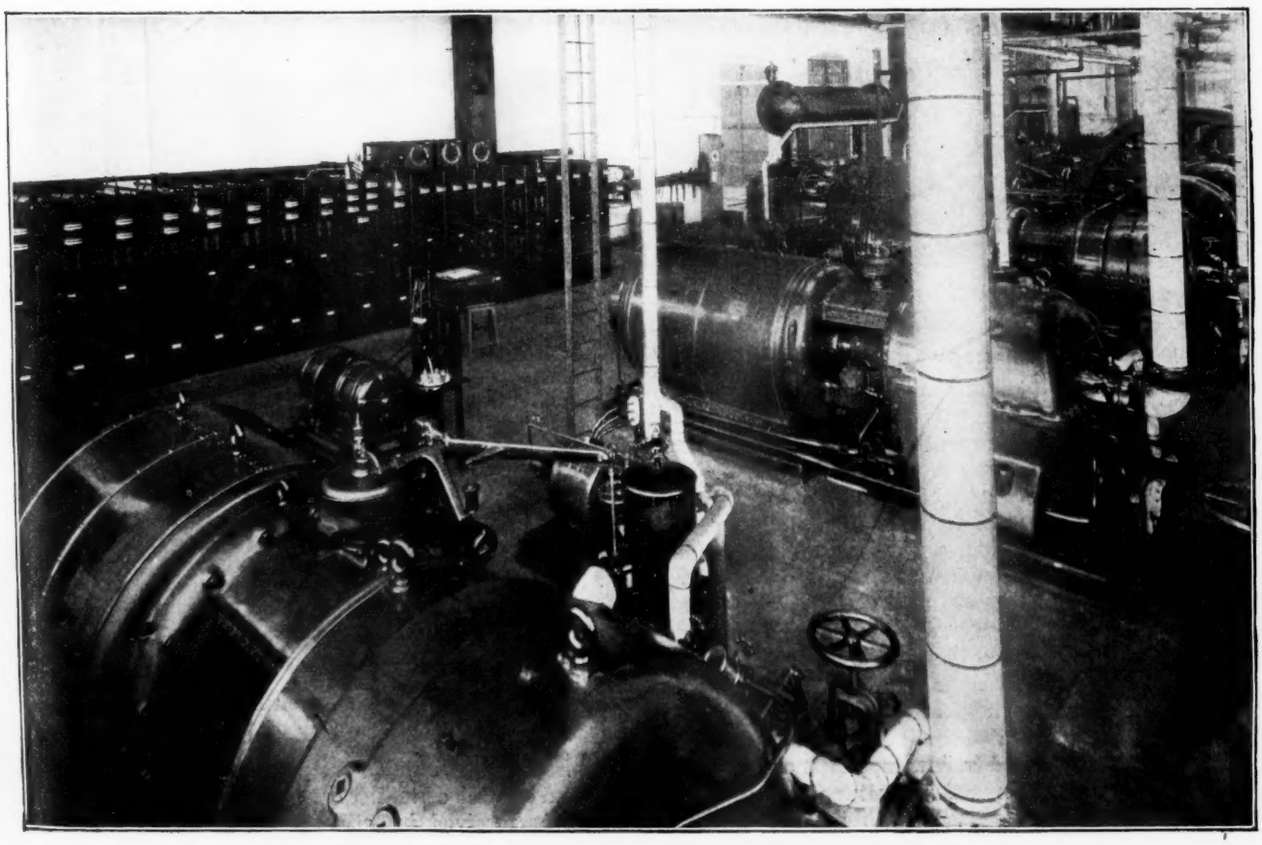


FIG. 3. INTERIOR OF TURBO-GENERATOR AND AIR COMPRESSOR ROOM

The City of Richmond, Va., had ordered one of these turbines for its municipal plant, which unit would soon have been on its way from the factory, but Richmond, to help win the war, sacrificed, as did private manufacturers who were to receive the other two units commandeered.

It will be noted later in this article that steam is applied directly to the compressors to produce high-pressure air instead of going through the intermediate steps of electric-power generation and synchronous motors for the compressors. Such an arrangement would have improved the power factor, but the saving did not warrant the investment, since power-factor correction can be obtained at any time by a synchronous or static condenser installation at less cost. However, if it had not been possible to locate the compressors in the power house and operate them condensing, synchronous motor-driven units would no doubt have been installed. Because of its greater flexibility, ease of transmission, ease of changing voltage and small transmission losses, the use of alternating-current was decided upon. The small amount of direct current required at the far end of the yard away from the old direct-current plant is obtained by means of a rotary-converter substation.

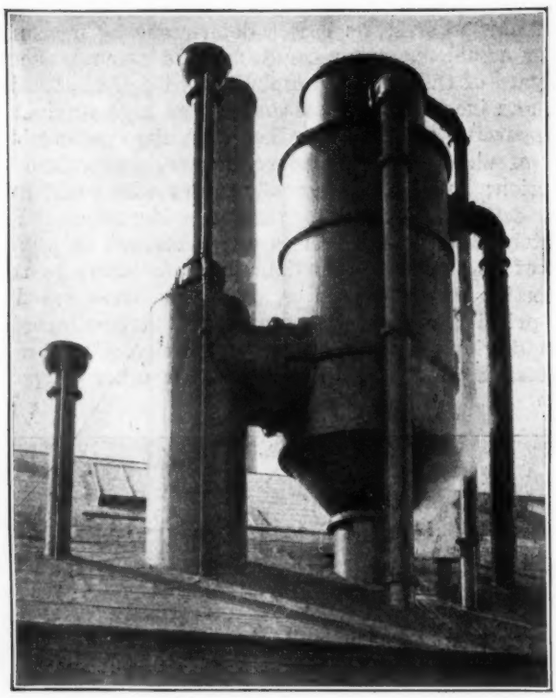


FIG. 4. BAROMETRIC CONDENSER ON TURBINES

The power house is 170 ft. wide by 200 ft. long, of standard steel construction, with concrete foundation, metal sash, ribbed-glass windows, tar-paper and slag roofing. In the power house the electric power is generated for general light and power distribution throughout the yard, shops and other buildings; air is compressed for use in pneumatic tools for riveting, chipping and calking and for miscellaneous uses about yard and in shops; steam is generated for industrial uses in shops and for heating shops and buildings; hot and cold water is pumped to all buildings for sanitary and drinking purposes; river water is pumped to buildings, shops, toilets and about the yard for all other than sanitary purposes and to supplement the supply of river water in case of emergency, pumps are kept in constant readines. to deliver an extra supply of water to fire pumps and sprinkler systems in all yards and buildings.

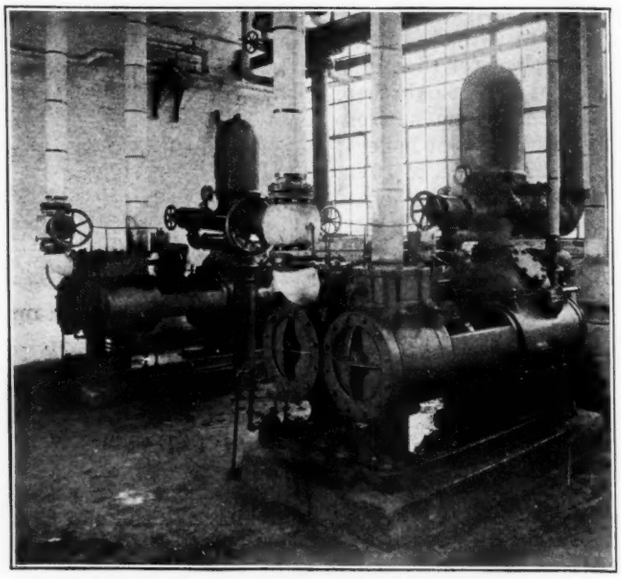


FIG. 5. UNDERWRITERS' FIRE PUMPS

In the new plant there are eight 500-hp. vertical water-tube boilers designed to operate at a normal working pressure of 175 lb. gage. Each boiler is fitted with a superheater to give 150 deg. F. superheat. The boilers are equipped with automatic stokers. Soot blowers are used and arranged so as to clean every square foot of boiler tube surface. Two brick smokestacks have been erected just outside the power house, each 175 ft. high and capable of taking care of five 500-hp. boilers.

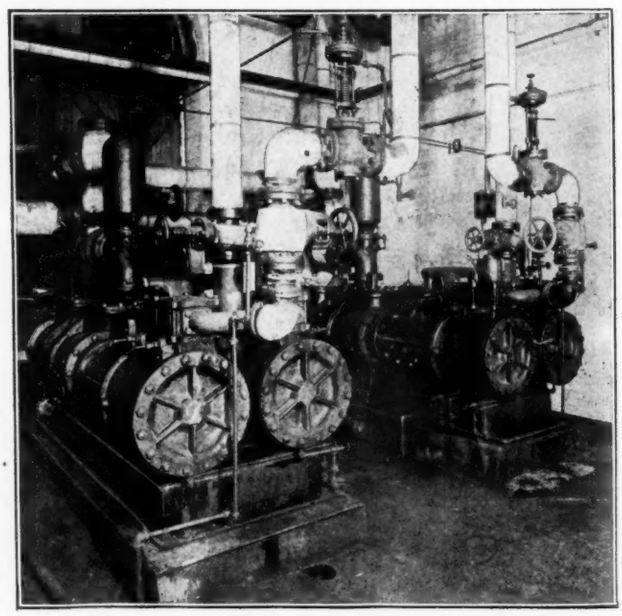


FIG. 6. DUPLEX BOILER FEED PUMPS

Coal is received by either boat or railway and is dumped into a hopper on the wharf; thence is conveyed

to a 50-ton per hour coal crusher which is located just outside the power house and is operated by a 30-hp. motor, from where it is lifted by a bucket conveyor and delivered upon a 20-in. belt conveyor which deposits it in the desired section of the coal bunker. From the bunker the coal descends by a gravity chute to the furnace of each boiler. The coal bunker has a storage capacity of 3,000 tons, or about a 30 days' supply for the power house. The steam main is a continuous overhead loop, Fig. 7, running over all the boilers, turbines, air-compressor engines, pumps, heaters, yard connection, etc. Steam-main and larger steam-supply connections to turbines, engines, pumps and yard connections are extra-heavy black wrought-iron pipe butt welded.

Spiral-riveted pipe was used on all low-pressure lines and was chosen on account of its lightness, less expense and ease of obtaining at the time. This pipe is serviceable only for low-pressure work, and in order to insure against leaks it was found advisable to give it at least two, preferably three, coats of Bitumastic paint.

There are four 1,955-cu.ft. per min. and three 5,715-cu.ft. per min. cross-compound, steam-driven two-stage, water-jacketed, intercooler compressors, compressing air to 110 pounds. To circulate the cooling water through the water jackets of the air compressors there is one 1,000-g.p.m. turbine-driven single-stage centrifugal pump and one 1,000-g.p.m. single-stage, double-suction, motor-driven centrifugal pump.

There are installed for generating alternating-current, one 1,250-kva. and two 1,875-kva. 60-cycle, 2,300-volt turbo-generators. For the excitation of the generators there are one 15-kw. and one 36-kw. 125-volt turbo-exciter sets and one 25-kw. and one 35-kw. 125-volt, compound-wound, motor-driven exciter sets.

A barometric condenser capable of giving 26 in. of vacuum when condensing 58,000 lb. of steam per hour serves the air compressors; and for the turbo-generators there is a barometric condenser capable of giving a 28-in. vacuum when condensing 75,000 lb. of steam per hour. It will be seen from Fig. 8 that all air compressors are piped into the same condenser, likewise one condenser serves all turbo-generators. Accompanying these condenser equipments there are two steam-driven and one motor-driven dry vaccum pumps, two turbine-driven centrifugal pumps and one motor-driven centrifugal pump.

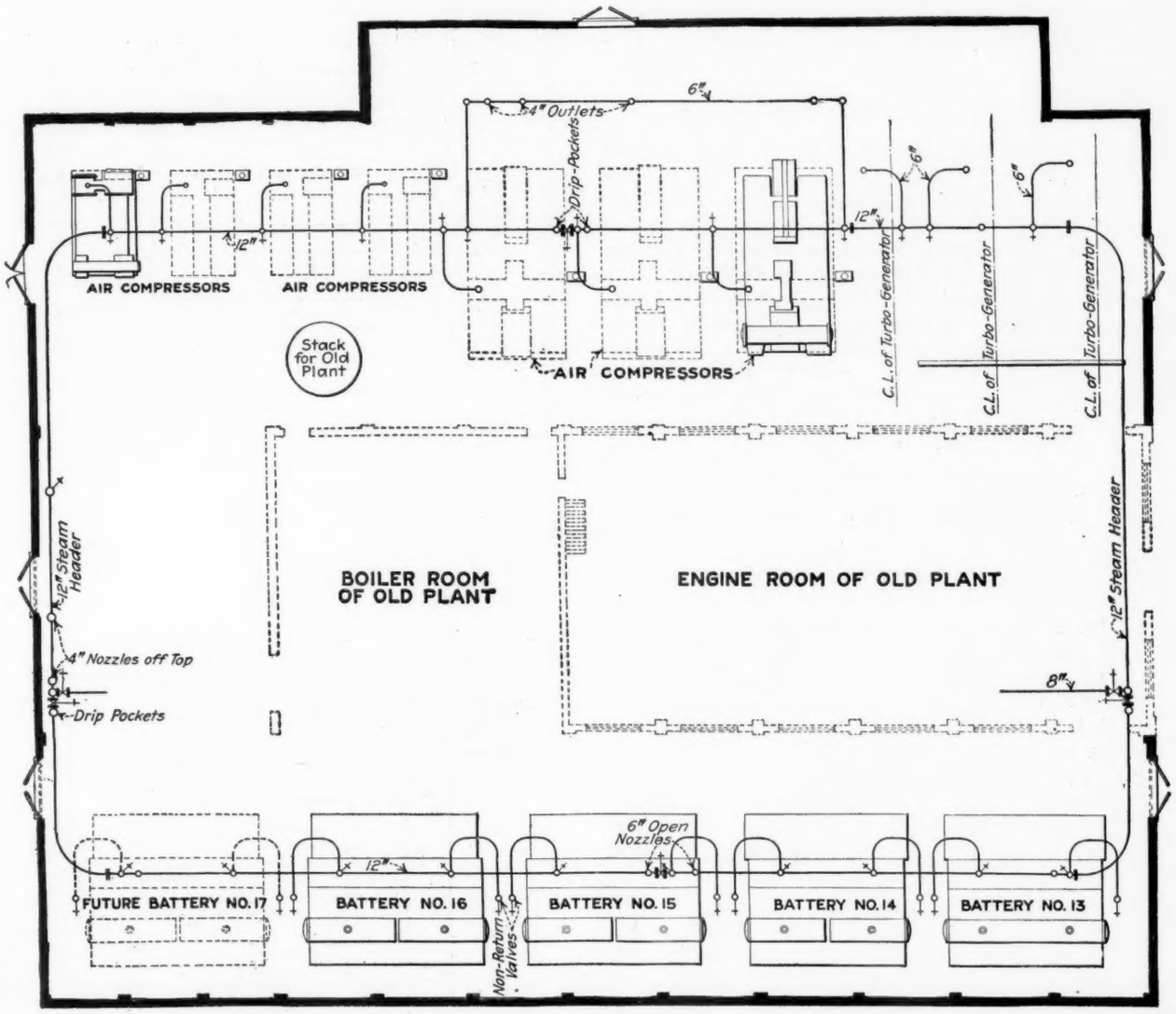


FIG. 7. GENERAL ARRANGEMENT OF HIGH-PRESSURE STEAM HEADER AND PIPING

Two hundred and fifty-volt direct-current power is generated in the old power house and distributed by underground cables to the several shops for operating cranes; 2,300-volt three-phase 60-cycle alternating-current power is generated by the turbo-generators in the new addition to the power house and distributed as such through underground cables to 14 substations suitably located about the yard, where it is transformed to the voltage best suiting the apparatus employed and conditions prevailing; 440-volt three-phase current is used for motors driving shop machines, pier cranes, and miscellaneous apparatus; 220-volt three-phase, for portable pier-pump motors; 110/220-volt single-phase for general lighting, and 250-volt direct-current for gantry and shop cranes and in the machine shops. On the whole system there is a total connected transformer load of 8,773 kva.

All Distribution Feeders Underground

There are no overhead wires in the yard to obstruct transportation and industrial operations. All direct-current crane feeders from the power house and rotary substation, and all high-tension alternating-current feeders from the power house to the several substations are lead-sheathed cables run in underground fiber ducts inclosed in concrete, with watertight manholes at intervals of about every 250 ft. and at sharp corners.

In the power house there are seven air compressors which are capable of compressing 25,000 cu.ft. of air per min. to a pressure of 110 lb. per sq.in. The air is transmitted to a manhole outside the power house through a 16-in. main; from there a 15-in. air main runs along the head of the twelve shipways a distance of 2,315 ft. On either side of each shipway there is a 4-in. branch air line with one 3-in. valve and 11 six-hose manifolds, giving each shipway two 3-in. and 132 1-in. hose connections. Along the bulkhead pier or fitting-out wharf there is a 6-in. air line from which are taken nine 3-in. hose connections or three 3-in. connections for each ship being fitted out. Branch connections are also run to each shop and building throughout the yard requiring air. The air mains are of black standard wrought iron or steel pipe, butt-welded and protected with one coat of non-corrosive paint. Anchors and expansion joints are placed at intervals of about 250 ft. to prevent dislodgement and rupture due to expansion, a three-tank air receiver of 1,280 cu.ft. capacity is placed in the power house and a receiver of 67 cu.ft. capacity on each craneway.

Air and Steam Mains Butt-Welded

The 15-in. air main, 2,315 ft. long, is butt-welded throughout with the exception of places where the copper expansion joints are installed, where a flange is welded onto the pipe. This pipe, after welding, when tested out on a pressure of 115 lb., was found to contain only one leak which when repaired put the pipe in good condition, and it has given no trouble since the early part of 1918.

The manner in which this pipe was welded was by machining the ends and chamfering at an angle of approximately 45 deg. until one-half the thickness of the pipe was removed at the butt. The two pipes were then placed together and the weld made with an oxy-acetylene torch. This same type of joint was used on the 12-in. steam header in the power house. Unless a steam main is properly blown out after it has been welded, it was our experience on this job that globules of metal on the inside of the pipe, produced by welding, are likely to come over and be harmful to the machinery supplied from the steam line.

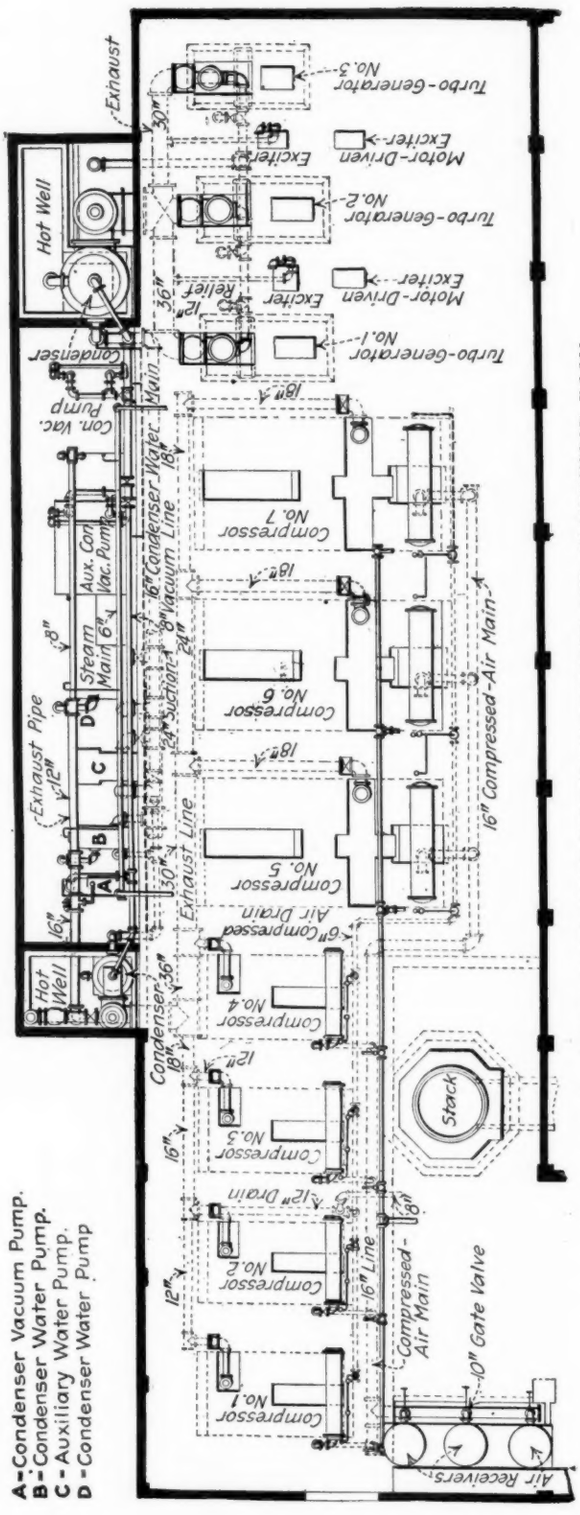


FIG. 8. GENERAL PLAN OF PIPING IN TURBINE AND COMPRESSOR ROOM

To supply the 15,000 gal. of water per minute required for boiler feed, condenser purposes, jacket water for the air compressors, fire protection, sewage and miscellaneous uses, there runs from the forebay to the power house one 24-in. and two 16-in. suction pipes.

This water is strained at the forebay by passing through strainers, so as to eliminate as far as possible the entrance of foreign matter into the equipment and piping systems.

So-called "river water" is drawn from one of these suction pipes and forced through at 6-in. yard main under a pressure of 100 ft. head by a service pump having a capacity of 600 gal. per min. This water main is connected to a 16-ft. diameter by 100-ft. high water tank, which has a capacity of 150,000 gallons. Hot water is supplied to the hospital, toilets, shops and other buildings at a temperature of 180 deg. F. This water is drawn from the Bristol water mains, heated in a pair of combined hot-water heaters and storage tanks, each of which is capable of heating 3,000 gal. per hr. from 50 deg. to 180 deg. F., and is pumped throughout the yard. Live steam for industrial use and heating purposes is supplied to all shops and buildings throughout the yard from the main power house through a 10-in. steam main which parallels the other pipe systems, and is heat insulated with a thick magnesia covering, and together with the hot water pipe and steam returns, is inclosed in a horizontally split terra-cotta pipe. This was constructed using the Underground Specialties Co.'s method of insulation of this type of transmission of steam and hot water.

A tunnel through the yard to hold all pipes, conduits and cables would have made operation easier, but to reduce this investment about 25 per cent all pipes, conduits and cables were buried with access to them only at manholes, and existing wires and pipes were used in practically 90 per cent of the places where they were found in the old structures of the Standard Cast-Iron Pipe and Foundry Co.

When all mechanical and electrical work was completed, there was a test conducted by the Emergency Fleet Corporation in conjunction with the Merchant Shipbuilding Corporation and the William Gordon Corporation, which resulted in an acceptance of the work. These tests were all in accordance with the American Society of Mechanical Engineers Code and the accompanying abstracts are of interest.

BOILER TEST

Economy

Water evaporated per lb. of coal as fired, lb.	7.547
Water evaporated per lb. of dry coal, lb.	7.639
Equivalent evaporation from and at 212 deg. per lb. of coal fired, lb.	8.955
Equivalent evaporation from and at 212 deg., per lb. of dry coal, lb.	9.063
Equivalent evaporation from and at 212 deg., per lb. of combustibles, lb.	11.013

Efficiency

Calorific value of 1 lb. of coal as fired, B.t.u.	13,451
Calorific value of 1 lb. of dry coal by calorimeter, B.t.u.	13,610
Calorific value of 1 lb. of combustible by calorimeter, B.t.u.	15,586
Efficiency of boiler, furnace and grate, per cent	64
Efficiency based on combustion, per cent	68

Heat Balance Based on Dry Coal

	B.T.U.	Per Cent
(*a*) Heat absorbed by the boiler (9.063 x 970.4)	8,795.0	64.6
(*b*) Loss due to evaporation of moisture in coal (1,230 x 0.012)	15.0	0.1
(*c*) Loss due to heat carried away by steam formed by the burning of the hydrogen (1,230 x 0.045 x 9)	498.0	3.7
(*d*) Loss due to heat carried away in the dry flue gases (29.6 x 0.24 x 410)	2,911.0	21.4
(*e*) Loss due to carbon monoxide	0.0	0.0
(*f*) Loss due to combustible in ash and refuse (0.177 x 0.322 x 14,600)	382.0	6.1
(*g*) Loss due to moisture in air (0.35 x 410x0.47)	48.0	0.4
(*h*) Loss unaccounted for	511.0	3.7
(*i*) Total calorific value of 1 lb. of dry coal	13,610	100.0

TURBINE TEST

Economy Results

	1,000-Kw. Turbine Normal Vacuum	1,000-Kw. Turbine Low Vacuum	1,500-Kw. Turbine Normal Vacuum
Superheated steam consumed, lb., by turbine per b.hp.-hr.	12.8	13.8	11.3
Superheated steam consumed, lb., per net kw.-hr.	19.40	21.28	17.04
Heat units, B.t.u., consumed by turbine per b.hp.-hr.	15,000	16,051	13,301
Heat units, B.t.u., consumed per net kw.-hr.	22,482	24,614	20,017

Efficiency Results

Per cent thermal efficiency of turbine	16.9	15.2	18.3
Per cent efficiency of Rankine cycle at superheat	28.2	26.7	27.7
Rankine cycle ratio, per cent	60.0	59.9	69.0
Net work, ft.-lb., per B.t.u. consumed by turbine	131.5	123.3	148.6

Principal Data and Results of Turbine Test

(1) Dimensions	1,000 kw.	1,000 kw.	1,500 kw
(2) Date—1918	July 13	July 13	July 10–11
(3) Duration, hours	3.5	2.5	16
(4) Pressure, lb. per sq.in., in steam pipe near throttle by gage	168.7	166.9	160.8
(5) Vaccum in condenser, inches mercury	26.97	25.49	26.7
(6) Degrees F. superheat of steam near throttle	97.5	101.2	112
(7) Total steam consumed, pounds per hour	18,346	20,343	25,768
(8) Revolutions per minute	3,570	3,600	3,568
(10) Kw. output	945.7	956	1,512.5
(13) Steam consumed pounds per kw.-hr.	19.4	21.28	17.04
(14) Heat consumed, B.t.u., per kw.-hr.	22,482	24,614	20,017

NOTE—All temperatures recorded above are average observed thermometer readings, and all calculations are based on steam tables using temperatures corresponding to the pressures.

AIR COMPRESSOR TEST

Speed

	5,715 Cu.Ft. Compressor	1,955 Cu.Ft. Compressor
Revolutions per minute	106.0	136.0
Indicated horsepower of steam end	937.0	283.0

Power

Gross air horsepower as indicated in air cylinders	877.0	256.0
Indicated friction horsepower	60.0	27.0
Percentage of I.-hp. lost in friction of machine	6.4	9.5

Capacity

	Cubic Feet	Cubic Feet
Compressed air delivered per minute reduced to atmospheric temperature and pressure	4,754.0	1,537.0
Volume of free air entering low-pressure cylinder per minute	5,099.0	1,590.0
Volume of piston displacement per minute at speed of test	5,507.0	1,662.0

Summary of the Development

To summarize, the power plant serves the yard complete and the housing development in all respects with the exception of steam for group heating at the upper end and electricity at the lower end. The heating at the upper end is obtained from a separate heating plant and the electric current at the lower end from the lines of the East Pennsylvania Gas and Electric Co., the public utility that serves Bristol. The object in dividing the electrical service for the housing is because at the time the plant was constructed it was the intention to make the lower section part of Bristol and retain the upper section as a private housing development as part of the shipyard. The advent of the town of Harriman with its new hotel, hospital, school, firehouse and other public necessities, has changed all this and created a thriving and prosperous community with its busy shipyard adjacent.

In concluding it should not be overlooked that in less than four months after September, 1917, when the order was issued to proceed with mechanical and electrical work, one boiler, one turbo-generator and two air compressors were installed and in operation. Since the armistice, under the direction of the Emergency Fleet Corporation and Merchant Shipbuilding Corporation, various improvements and expansions have been made, a 60-ton electric crane has been added at the fitting-out wharf, the steel-storage area has been trebled, several buildings have been added and the temporary central heating plant in the housing development has been replaced with a more permanent structure. Under war pressure we were forced to build ships; today this industry is growing on a healthy peace basis, a war product that is helpful to us in competing for world markets.

How a Smoke Cloud Forms

By Osborn Monnett

HAVING in mind the facts as set forth in the foregoing sections, it is interesting to note the process of smoke formation over Salt Lake City and to draw conclusions that will aid in attacking the problem. This can best be done late in the fall, before the mornings get too dark to obscure the action of the smoke cloud as it forms, as shown in the illustration. On such mornings, if a point of observation is selected overlooking the city before daylight, it will be noticed that the city is perfectly clear, street lights being visible as far as the eye can reach.

About 6 o'clock in the morning, while it is yet quite dark, a smoke cloud will be seen forming over the business portion of the city. This will be observed from the fact that lights beyond this section will be obscured, as it is yet too dark to see the smoke itself. In ten minutes this cloud has increased in size and density until the more prominent lights in the downtown section have become obscured, while the lights in the outlying section are perfectly visible for miles.

By 6:20 the cloud has entirely covered the downtown section of the city and reached to a considerable elevation, becoming visible as daylight approaches. About the time that the smoke cloud reaches the maximum elevation, a flattening out process seems to occur and the cloud spreads itself over the city with great rapidity, as can be noted by the gradual obscuring of the street lights as the progress of the cloud is marked. Initial formation of the smoke cloud is made within the zone of highest concentration, and is produced by the large industrial and heating plants in this district building up their fires and getting up steam for the day's run.

An interesting and graphic account of the way the smoke cloud forms over Salt Lake City. This chapter from the report of the smoke-abatement investigation of that city is published with the permission of the director, Bureau of Mines.

By 6:30 the city is thoroughly covered with a dense, permanent smoke cloud, formed in a half-hour by the large smokers downtown, which cloud remains over the city until the air currents in the afternoon cause it to be dissipated. Illustration of this smoke cloud formation is shown in the sketch.

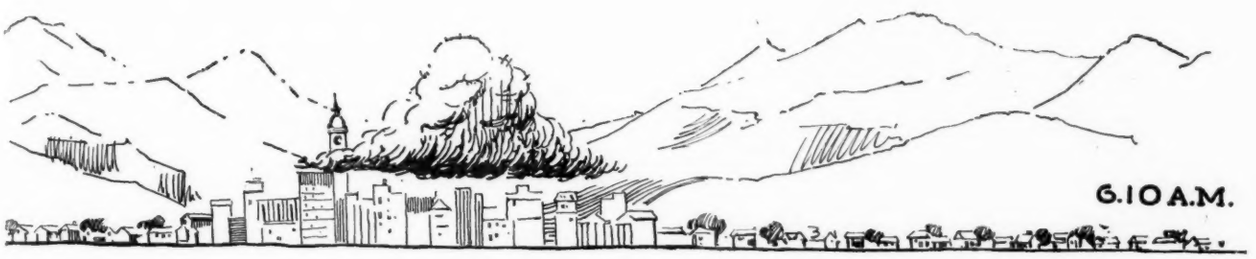
By this time it has become daylight and the first thin fingers of smoke are beginning to rise from a residence here and there. A swift trip through the residence section at this time of day will disclose only a very few residences smoking, although the sections passed through will be thoroughly covered with the smoke cloud which has been formed downtown and flattened out over the city before the domestic fires have been disturbed. Thus it is that the householder, when he rises in the morning, attributes the smoke which he sees in his vicinity to the residences in that vicinity. Later on in the morning the residences do contribute their share to the general smoke situation, but so far as the original smoke cloud is concerned they have nothing whatever to do with its formation. This early morning smoke, made without any supervision whatever, generally with the most careless methods of firing, is responsible for filling the valley in a half-hour with thick, heavy smoke.

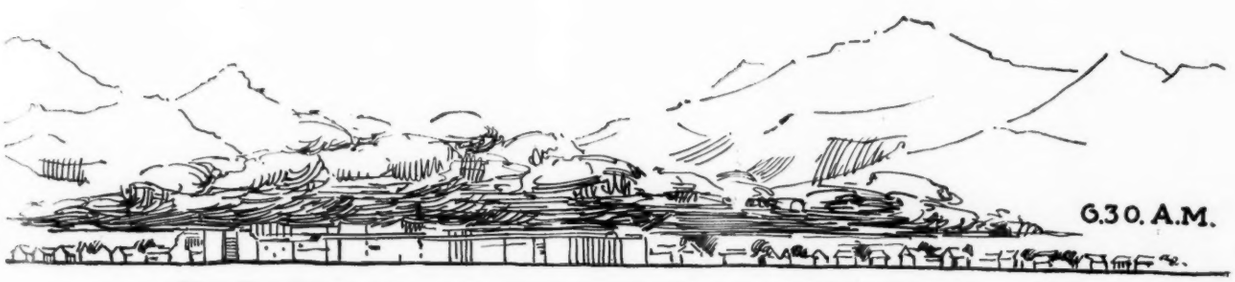
Any scheme that aims to reduce the smoke nuisance of the city must be based primarily on the prevention of this early morning smoke. As this smoke is produced before daylight, the ordinary methods of smoke observation will not suffice. Rather, a system of policing must be developed whereby these large smokers are supervised during the early morning hours, their operators being made to realize that they will be checked up on their performance and that an inspector may drop in upon them at any moment and that they must therefore use all the equipment with which they are provided for smoke-abatement purposes. This supervision must aim at the education of the firemen in charge of the plants with respect to the starting of fires without dense smoke. Also, the cleaning of fires without the production of dense smoke must be taught, there being standard methods controlling such operations which can be used successfully for this purpose.

At the same time equipment should be provided which will enable the fireman to know the condition of the top of his stack. Such equipment is known as a smoke indicator or periscope and can be installed in the boiler room and will show at a glance whether the stack is smoking. It is absolutely essential that all important plants be equipped with a device of this character, as most of the smoke is made at such time that, even if the fireman wished, he could not get an adequate idea of whether or not his stack was smoking, though he should take the trouble to go out and look. Furthermore many of these plants are in basements, making it impracticable for the fireman to see his stack, and unless there is some provision for his information he will not know whether the means taken are sufficient to keep down smoke.

This condition is unique in smoke-abatement work and is brought about by the unusually low wind velocity in Salt Lake City during winter time. Ordinarily the smoke made before daylight in the average city is entirely dissipated before business hours, but in Salt Lake City the large volumes of smoke made at this time form the basis and backbone of the smoke nuisance throughout the remainder of the day.

With this initial smoke cloud eliminated, a wonderful improvement in atmospheric conditions will be noted at once and a condition brought about similar to that noticed on a Sunday morning when the industrial smoke is at a minimum; namely, a light haze in the valley for which residences will be mainly responsible. It will then be a simple matter to concentrate on the remaining classes of smokers to reduce them to a minimum in connection with regular smoke observation throughout the daylight hours.





SHOWING THE PROGRESSIVE FORMATION OF A SMOKE CLOUD

The illustrations show, first, how the small cloud of smoke forms in the industrial section of the city, in the early morning, how it gradually grows larger and then rapidly spreads and envelops the whole city, forming the backbone of the smoke nuisance. Care in early morning firing would very largely eliminate the evil during the rest of the day.

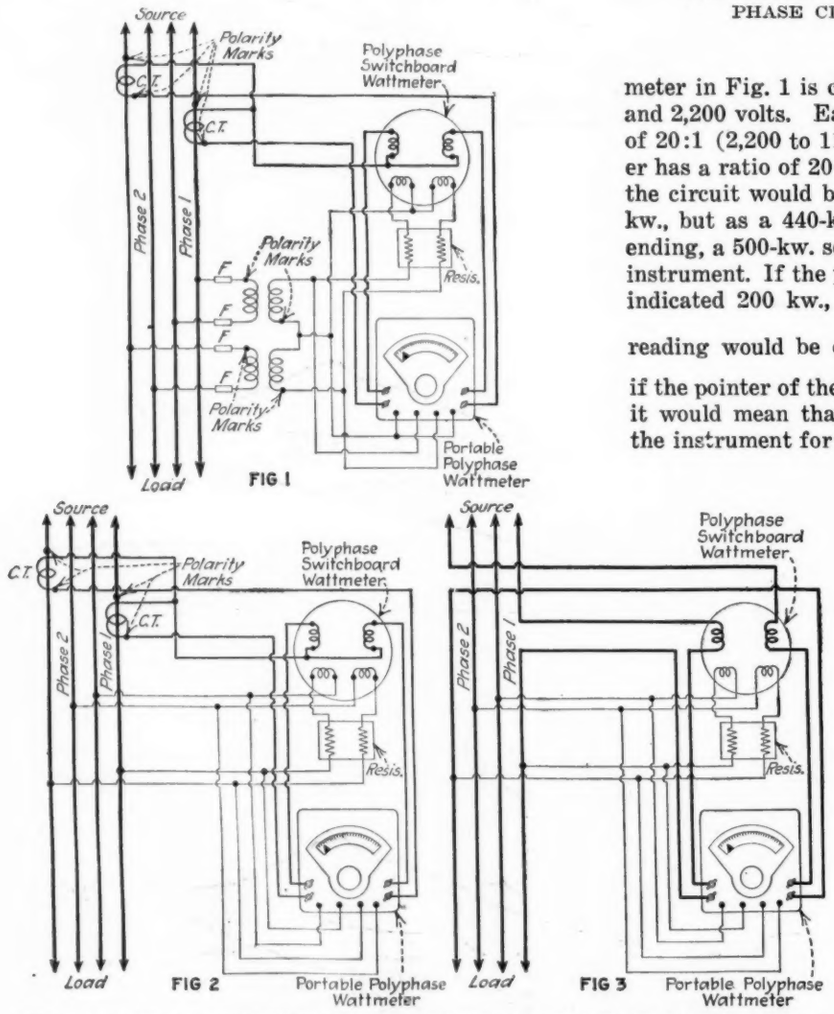
Checking Four-Wire Two-Phase Switchboard Wattmeters

By H. C. Yeaton

TO CHECK a four-wire two-phase switchboard wattmeter by the polyphase-wattmeter method, connect a portable polyphase wattmeter in the circuit as shown in Figs. 1, 2 or 3. The current terminals of the portable wattmeter are connected in series with the current terminals of the switchboard wattmeter, and the potential terminals of the portable meter are connected across the potential circuits. When current is passing through the primary of a current transformer, the secondary circuit should be short-circuited if any apparatus is to be disconnected from the circuit.

The scale of a four-wire two-phase switchboard wattmeter is usually marked in primary watts, which are actual watts or kilowatts of the circuit, and, in a balanced circuit, having unity power factor are equal to the *primary amperes* $\times$ *primary volts* $\times$ 2.

The calibrating watts of a four-wire two-phase wattmeter are the watts required to make the pointer deflect from zero to full scale and equal *Scale Range* $\div$ *Potential-Transformer Ratio* $\times$ *Current-Transformer Ratio.*



FIGS. 1, 2 AND 3. CONNECTIONS FOR CHECKING TWO-PHASE SWITCHBOARD WATTMETERS ON TWO-PHASE CIRCUIT

If the switchboard wattmeter is used with only current transformers, as in Fig. 2, the scale range should be divided by the current-transformer ratio only and not the product as in the formula to determine the calibrating watts. In case the switchboard wattmeter is not used with transformers, Fig. 3, the scale range would be marked in primary watts, which would be the calibrating watts. Therefore, by checking the calibrating watts of the switchboard wattmeter with the portable instrument, the accuracy of the former may be determined. Suppose that the four-wire two-phase wattmeter in Fig. 1 is connected in a circuit of 100 amperes and 2,200 volts. Each potential transformer has a ratio of 20:1 (2,200 to 110 volts), and each current transformer has a ratio of 20:1 (100 to 5 amperes). The watts of the circuit would be 2,200 $\times$ 100 $\times$ 2 $\div$ 1,000, or 440 kw., but as a 440-kw. scale would be rather an uneven ending, a 500-kw. scale would probably be marked on the instrument. If the pointer of the switchboard wattmeter indicated 200 kw., then the calibrating watts for this reading would be equal to $\frac{200,000}{20 \times 20}$ or 500. Therefore if the pointer of the switchboard meter indicated 200 kw. it would mean that only 500 watts were impressed on the instrument for this deflection. If the portable wattmeter connected on the secondary of the transformers indicated 500 watts, it would show that the switchboard instrument was indicating correctly.

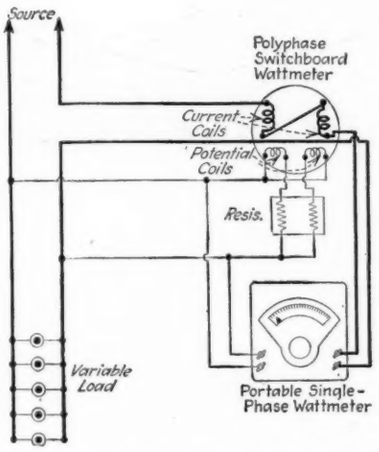


FIG. 4. CHECKING POLYPHASE WATTMETER ON SINGLE-PHASE CIRCUIT

The foregoing method of checking gives only one point, as it probably would not be convenient to vary the primary load, which may be a feeder circuit. However, several points may be checked during the day as the load varies on the circuit.

If it is desired to check more than one point on the scale, short-circuit the current transformers and disconnect the instrument from the circuit. Then connect the switchboard wattmeter on a single-phase circuit, using a variable load. A single-phase wattmeter should be connected in the circuit, as shown in Fig. 4. In the figure it will be noticed that the current coils of the switchboard instrument are connected in series, and the potential coils are connected across the circuit.

The current winding of the portable single-phase

wattmeter is connected in series with both current windings of the switchboard instrument, and the potential terminals of the portable meter are connected across the potential. Therefore, as there are two elements in the switchboard wattmeter and one element in the portable, the total watts impressed on the polyphase meter will be twice those impressed on the single-phase meter. Consequently, the calibrating watts per element of the switchboard wattmeter will equal *Scale Range* ÷ *Current-Transformer Ratio* × *Potential-Transformer Ratio* × 2. However, if the switchboard wattmeter is used with current transformers only, then only the current-transformer ratio would appear in the formula. In case the switchboard wattmeter is not used with transformers, the scale would be marked in primary watts, which would also be the calibrating watts, and only the numeral 2 would appear in the denominator of the formula. Therefore, by determining the calibrating watts of the polyphase wattmeter from the formula, the scale readings may be checked with the portable single-phase wattmeter.

Suppose that it is required to check the four-wire two-phase wattmeter, Fig. 1, at the readings 100, 200, 300 and 400 kw. Connect the instrument on a 5-ampere 110-volt single-phase circuit, as shown in Fig. 4. The calibrating watts per element of any particular reading equals *Scale Reading* ÷ *Potential-Transformer Ratio* (20) × *Current-Transformers Ratio* (20) × 2.

Substitute the readings 100,000, 200,000, 300,000 and 400,000 in the numerator and divide by the denominator 20 × 20 × 2 (800) and we obtain the following:

Switchboard Polyphase-Wattmeter Reading in Kilowatts	Calibrating Watts per Element of the Switchboard Wattmeter	Portable Single-Phase Wattmeter Reading, Watts
100	125	125
200	250	250
300	375	375
400	500	500

Other readings can be checked in like manner, although four or five readings are usually sufficient.

Bessemer O.D. Semi-Diesel Engine

One of the greatest markets for semi-Diesel or surface ignition engines is the oil field industry. In many fields it is customary to install natural gas engines for pumping purposes. However, since the supply of gas steadily decreases the trend is toward the oil engine. Several builders now place a large percentage of their engines in this work.

The Bessemer Gas Engine Co. has developed a special type of oil engine for the oil fields. A cross-section of the O. D. engine is shown in Fig. 1. The ignition of the fuel is secured by means of the mercury vaporizer described in *Power* of July 13, 1920.

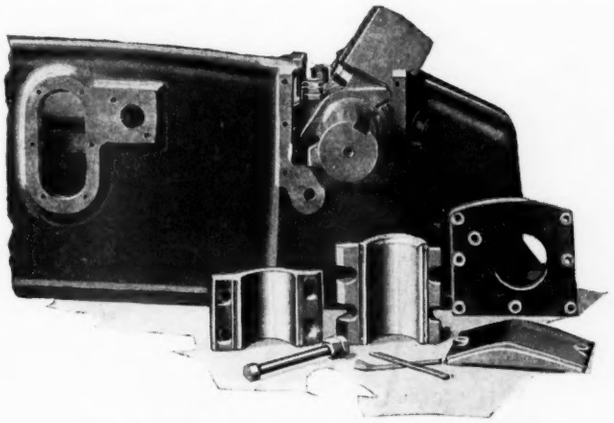


FIG. 2. MAIN BEARINGS OF O. D. ENGINE

The engine frame is considerably lighter than that of the standard Bessemer oil engine, but the cast iron is so placed as to hold the stresses below 1,800 lb. per sq.in. As will be understood by those familiar with oil field conditions, a successful engine must be rugged in design and must possess as few moving parts as possible. The

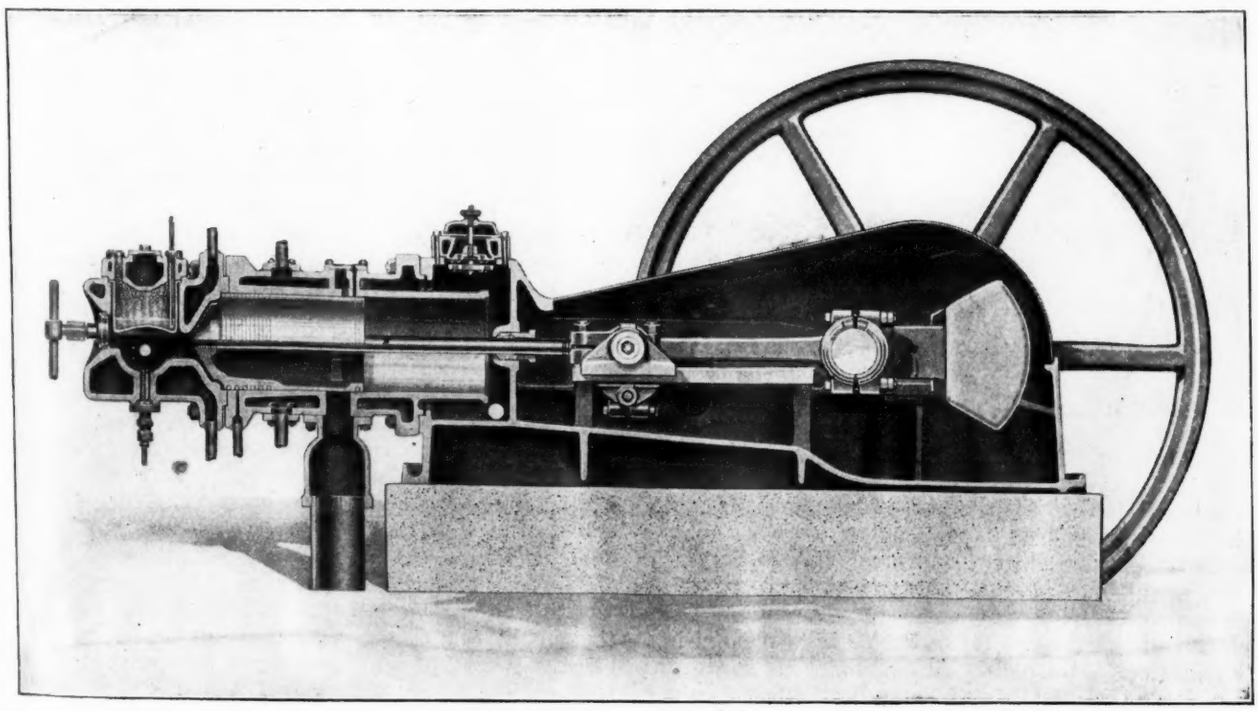


FIG. 1. BESSEMER O. D. TYPE OIL ENGINE

bearings are of the two-piece design and are deeply seated in the frame. The pressure is against the cast iron housing and not against the bearing cap bolts, as is frequently the case.

The crosshead, Fig. 4, is of the slipper type and is adjustable. In the oil fields where much grit is blowing about, the crosshead wear is rather large; this design of guide is much superior to that of the bored guide. The

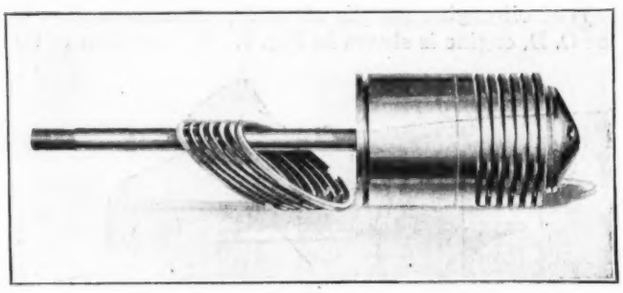


FIG. 3. O. D. ENGINE PISTON

connecting rod follows the usual Bessemer design, having a bushed wristpin bearing and a marine crankend.

The piston, Fig. 3, has no deflectors. To secure cylinder scavenging the outside scavenging air ports are directed inwardly at right angles to a plane passed vertically through the cylinder. The inner or cylinder ends of these ports enter the adjacent pair of ports. The air currents passing through the outer pair of ports encounter the portion of the air passing through the other air ports and give the entire air charge a twirling motion that effectually scavenges the entire cylinder of the exhaust gases. The air suction valve is of the poppet type, being somewhat similar to the Bessemer Corliss design of air valve.

The O. D. engine is a radical departure from the Bessemer traditions in that it is a dry engine, or an engine without water injection. The manufacturer still

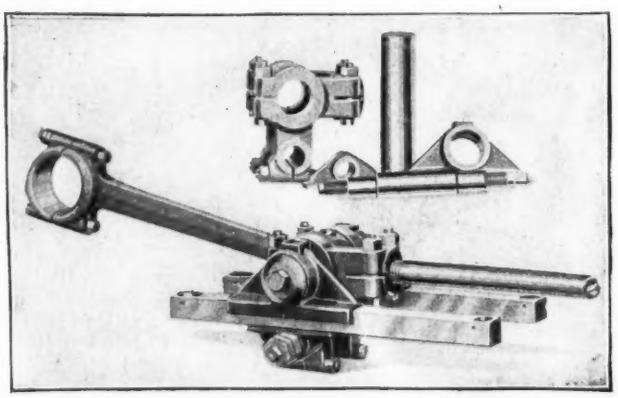


FIG. 4. CROSSHEAD OF O. D. ENGINE

adheres to the principle of water injection and states that it was eliminated in this engine on account of the conditions under which the engine must operate. In most of the oil fields the water is very bad carrying a large percentage of grit and dirt. The water would prove very detrimental to the engine if introduced into the cylinder. Consequently the dry engine is superior for this class of work. It is seldom that an oil field engine must pull its rated load, and there exists but little danger of preignition that so often occurs in dry engines on heavy loads.

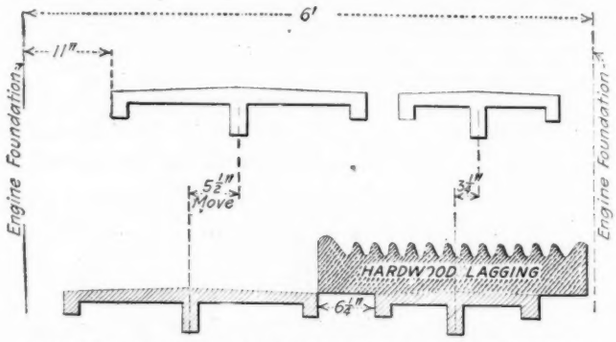
The mercury vaporizer is especially advantageous in performing work where the load may be very small for considerable periods of time. The constant temperature maintained by the mercury insures positive ignition of the fuel charge at all loads.

While the Bessemer Co. offers this engine only in the lower powers a 200-horsepower O. D. engine is in daily operation in their own power plant and carries its rated load without any signs of preignition. The cylinder size of this unit is such that piston cooling was deemed desirable. The cooling is obtained by oil circulation.

Changing Flywheel from Belt to Rope Drive

BY R. J. NAGLE

More power was required than a flywheel-driven 20-in. belt would transmit. The flywheel construction being of ample proportions to safely withstand the load required, it was decided to place a 6-in. hardwood lagging over the rim of the wheel, as shown in the



FORMER AND PRESENT POSITION OF FLYWHEELS

sketch, thus increasing the diameter from 20 to 21 ft., and to extend the lagging 6 in. out over the edges of the rim, as shown, thus increasing the width of the face from 20 to 32 in. The lagging, having been shaped to conform to the crown-faced rim of the wheel and secured in place, was turned off and grooved on the face for 12 wraps of 1⅝-in. rope.

To apply the lagging it was necessary to move two flywheels to new positions on the shaft. The wheels were constructed in eight sections, and the hubs were forced on the shaft. One wheel was 20 ft. in. diameter with a 20-in. face; the other was of the same diameter with a 32-in. face. With a hydraulic jack having a ram approximately 10 in. in diameter and built to withstand a pressure of 250 tons per square inch, and the necessary tie bars and strong-back, a force of 250 tons was applied, but the wheels refused to move. The rim and hub bolts of the wheels were slacked off to allow for expansion and two kerosene blowtorches, having burners approximately 6 in. in diameter and 12 in. long, were procured. The shaft was covered with burlap and kept wet with a stream of water.

The blowtorches were then played all around the wheel hub, one on either side. After the hub was thoroughly heated, the shaft having been kept comparatively cool, pressure was again pumped up on the jack and the wheels were moved, one at a time, to the required position.

Rewinding A Direct-Current Armature

By W. A. HEFNER

The rewinding problem is approached from a practical standpoint. Taking a specific case as an example, the process is followed through from stripping the old coils off the armature to turning off the commutator after the new windings have been completed.

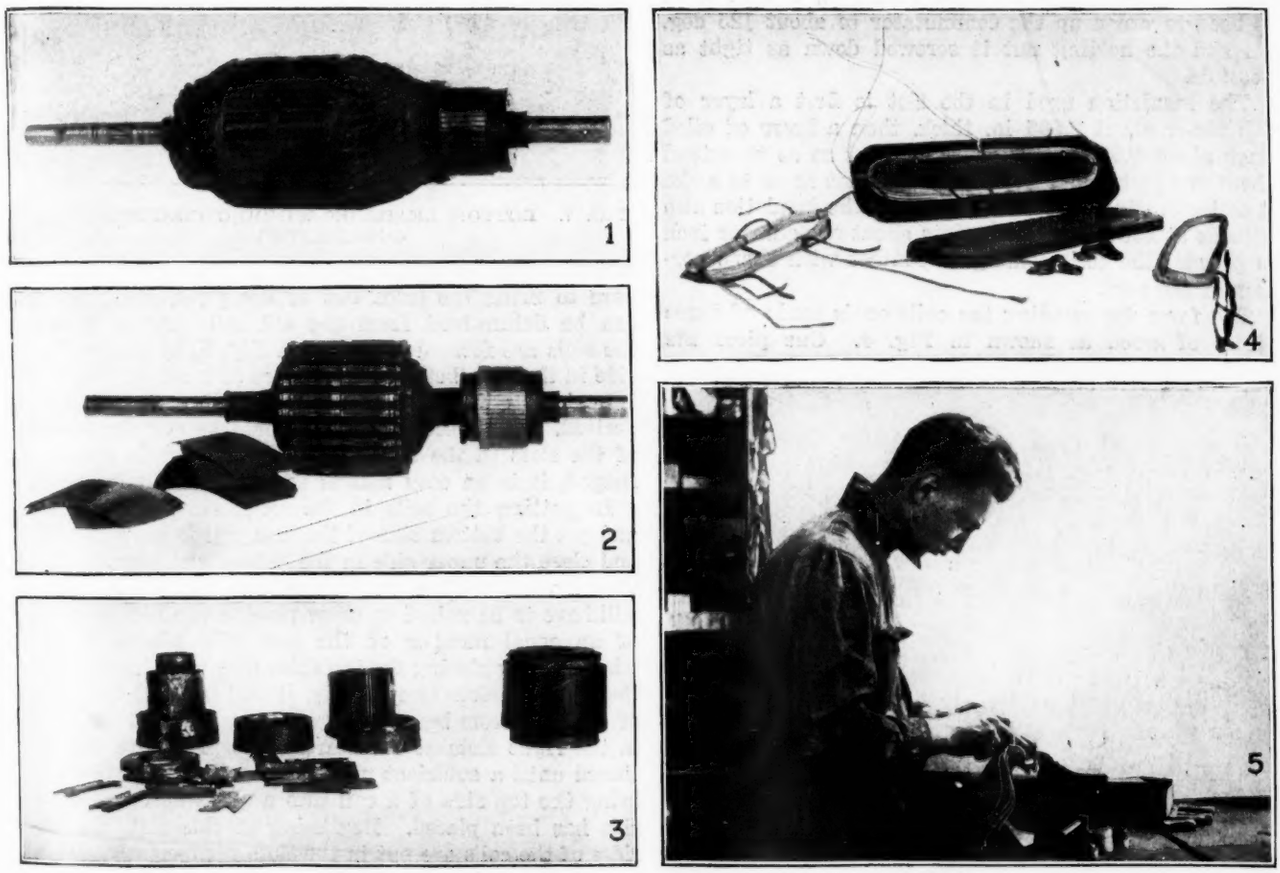
IN REWINDING a direct-current armature, the procedure is practically the same in each case, irrespective of the size of the machine. The dimensions of the armature would affect chiefly the number of turns and the size of wire in the coils. Where, in general, the coils in a small armature will be wound with a comparatively large number of turns of small-sized wire, the coils in a large armature will be wound with a small number of turns of large copper. Nevertheless, the events in rewinding vary only slightly with the different sizes. In this article will be discussed the rewinding of the armature shown in Fig. 1, the coils of which are wound two in parallel.

When an armature is to be rewound, the first thing to do is to remove the leads from the commutator. It is necessary at this time to determine the pitch of the coil leads to the commutator. This is easily done by placing a straight-edge on the center of any one of the slots and marking the commutator bar that lines up with this slot. Then count the number of segments between the marked bar and the segment to which the coil leads from one of the coils in this slot are connected. With this information at hand, it will be a simple matter to connect the new winding up to the commutator in the same relation as the old one was.

After the leads have all been unsoldered, break the armature band wires that hold the coils in place and carefully remove four coils for samples. One coil is kept as a pattern of the shape of the coils. The second coil is pulled out into an oblong to give the dimensions, for making a form to wind the new coils on, as in Fig. 4. The other two coils are opened up and used to determine the number of turns, number of conductors wound in parallel, size and amount of wire in the coils and the kind of insulation on the wire. With the foregoing information obtained, the remainder of the coils may be taken off in the easiest way possible, after which the core is cleaned and the thickness and kind of insulation in the slots noted. Before all the coils are taken off, the spread of the coils must be determined; that is, the number of slots spanned by one coil.

With a hacksaw blade ground to a thickness of the wire in the armature coils, the slots in the commutator, where the leads are soldered, are cleaned out. This makes it easy to put the leads of the new winding in place before soldering.

A test is next made on each pair of commutator bars



FIGS. 1 TO 5. VARIOUS STAGES IN THE PREPARATION OF AN ARMATURE FOR REWINDING

with a lamp to see that they are clear of short-circuits, and each segment is tested to the cast-iron shell for grounds. In case the mica is broken down between the segments, the commutator is taken apart by removing the screws or nuts that hold the "V" rings in place. After removing the latter, any or all of the segments may be easily taken out. With a segment as a pattern, new micas are cut, and with these replacing the old ones that were broken down, the commutator is re-assembled.

In putting together the commutator, the copper and the mica segments are assembled in place on one of the "V" rings, as in Fig. 3, then the front "V" ring is very carefully put in place and the nut that holds the commutator together is tightened down. This nut is first screwed down just sufficient to hold the mica together, and the segments tested to see if they are clear of short-circuits or grounds. If the commutator insulation proves to be in good condition, a blow-torch is used to warm up the commutator to about 125 deg. F., and the holding nut is screwed down as tight as possible.

The insulation used in the slot is first a layer of fish paper about 0.005 in. thick, then a layer of oiled linen about 0.005 thick. These are cut so as to extend about one inch above the top of the slots so as to make it easier to slide the coils into place. The insulation also extends at both ends of the slots about one-quarter inch to prevent the coils coming in contact with sharp corners of the core.

The form for winding the coils on is made of three pieces of wood as shown in Fig. 4. One piece the

FIG. 6. TOP SIDES OF FIRST COILS RAISED SO AS TO PUT DOWN BOTTOM SIDES OF LAST COILS

size of the inside of the coil is shaped and nailed to a side which is about one inch larger all around than the center around which is wound the coil. The other side is held in place and three holes are drilled through, one in the center for mounting the forms and one at each end, through which bolts are put with wing nuts on, to hold the loose side in place. Four slots are cut in the sides of the form down to the center core. The slots are for putting pieces of cord in to tie the coils with before removing them from the form. In winding the coils, 4-in. long pieces of cord are cut and one slipped in each slot of the form. The end of the wire is slipped into the slot nearest to the beginning of the coil and the form revolved until the required number of turns are obtained. The four pieces of cord are then tied and the loose side is taken off and the coil re-

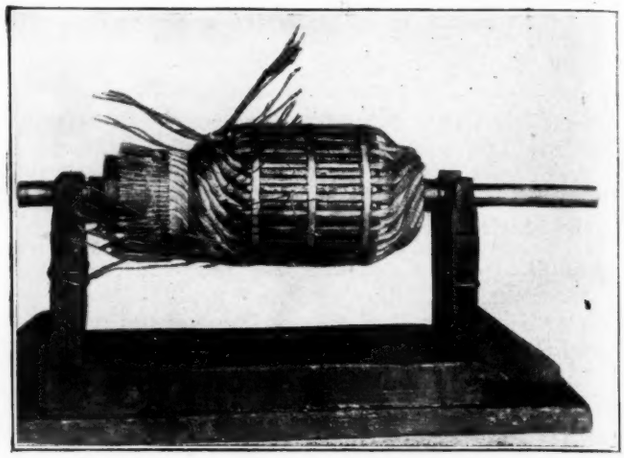


FIG. 7. BOTTOM LEADS OF WINDING CONNECTED TO CUMMUTATOR

moved from the core. The coil is then taped, making sure to bring the leads out at the right place, which can be determined from the old coil. After taping, the coils are formed as shown in Fig. 5, by placing one side in the vise, between two pieces of wood and holding two pieces on the other side and pulling to the shape desired. The pieces of wood should be cut the length of the slots in the armature. With the coils properly shaped, it is an easy matter to put them in the slots.

In putting the coils in the slots, start at any slot and put the bottom side of the first coil in permanently, and place the upper side in the proper slot temporarily. The top sides of a number of the first coils placed will have to be raised to allow placing the bottom sides of an equal number of the last coils placed in the winding. By placing the top sides that must be lifted in their proper slots temporarily, it will prevent the form of the coils from being changed, as well as get the coils in the right slots at the start. This procedure is continued until a sufficient number of coils are in place to bring the top side of a coil into a slot where a bottom side has been placed. Beginning at this slot, the top sides of the coils are put in the slots permanently. This process is continued until the slot that contains the top side of the first coil is reached, then all the top sides that were placed temporarily are raised and forced up just far enough to allow sliding the bottom sides of the last coils under and putting them in place. After the bottom sides of these last coils are placed, the top sides are put down as in Fig. 6. One care that must be observed is that the coil must be placed in the slots in succession and worked in one direction around the armature.

The coils should now be tested for grounds, open circuits and also for short-circuits between coils. If this test shows all coils to be clear, then all excess slot insulation is cut off where it extends above the core and the armature is banded, using any one of the various methods for banding, but making sure that the bands are put on tight and well soldered.

Connecting the leads to the commutator is done by first placing a straight-edge on any one of the slots and marking the commutator segment that is in line with this slot. Then, from the data taken before stripping the armature, find out how many bars to the right or left of the marked segment the first bottom lead must be connected. Beginning at the slot opposite the marked segment, take one of the bottom leads and connect it into the segment determined by count. In this winding two coils are wound in parallel, therefore there will be two bottom and two top leads coming from each slot. Either one of the bottom leads may be connected first, then the other in the adjacent segment. This is continued until all the bottom leads are connected. Each coil should be tested for grounds, open-circuit and short-circuit, before and after connecting. In this way any defect in the coils will be detected before the coil is connected into the winding. Since there are two coils wound in one, it is a good scheme to locate the leads of one coil by test in each group and mark the lead with a little shellac or paint. This will greatly simplify making the connections to the commutator. In such case, when the bottom leads are put down, care should be exercised to have every other lead a marked one; that is, if the unmarked lead is put down first in one pair of coils, then it must be connected first in all coils.

After all the bottom leads are down, the throw of the top leads to the left or right is determined and they are connected. Where armatures are parallel wound, as in this case, the first top leads will be connected to the segment adjacent to the bottom lead. Where there are two coils wound in one and the leads of one coil marked and the other unmarked, the top lead of the marked coil will connect to the same segment as the bottom lead of the unmarked coil. After this the leads can be put down in succession around the commutator, alternating unmarked and marked terminals. If the connections are made properly, a marked and an unmarked top and bottom lead will come into each segment.

When the leads are all down, they should be soldered, making sure that the solder runs into the slots to insure a good connection between the windings and the commutator bars. It is good practice when soldering the leads to the commutator to have the back end of the armature higher than the commutator; then the solder will not tend to flow in back of the segment and cause short-circuit between bars. After soldering, the commutator is turned down and examined carefully to find and remove any copper or solder that may have been drawn over from one segment to the other. The armature is then tested with a millivoltmeter or telephone receiver, for defects such as short-circuit, open-circuit, grounds and high-resistance contact. If the coils have been properly connected and insulated, the complete winding should test out clear. The last step in the process is to give the armature a coat of insulating paint and bake it in an oven, after which it is ready for service again.

Operation and Adjustment of Turbine Machinery

By EUSTIS H. THOMPSON
Consulting Engineer, Baltimore, Md.

How would you konw that a charge of water was coming over into the turbine from the boilers? What does occasional poor regulation indicate? When the blades accumulate a coat of scale or sediment how does the turbine act? If the machine has lost its balance gradually, what may have been the cause? These are but a few of the many specific troubles dealt with in this article which is the fifth of the series.

STEAM troubles are usually more bothersome than dangerous. Leaks in the system seem to be the most familiar form. Major troubles are guarded against by design, installation and operation, so that usually they are conspicuous by their absence. Although steam machinery has been thoroughly developed in all directions during the century or more in which steam has been in harness, it will not operate with satisfaction unless given close attention. Symptoms of trouble, due to wear or other factors, should be carefully noted so that proper steps may be taken for the protection of the units.

Characteristics of Steam Troubles

1. Sudden slowing down of a small machine, accompanied by a small amount of vibration and sometimes considerable leakage from the shaft packing. Larger machines slow down less, but vibrate more easily. Very large machines slow down less, but vibrate considerably, and in extreme cases cause stripping of the blades. This behavior usually indicates a charge of water coming over with the steam. The remedy is the prevention of boiler priming, thorough draining of pipes or perhaps elimination of water pockets in the steam line, use of a proper steam separator.

2. Vibration beginning slowly and gradually increasing. Small machines slowing down, though the speed of large machines is not necessarily affected. Cause, water collecting in the turbine casing, owing to improper draining and to wet steam. Remedy, correction of turbine drainage.

3. Regulation occasionally poor with inability to carry load. Cause, low steam pressure or insufficient vacuum.

4. Inability to carry load, at first slight and gradually becoming worse. Cause (a), sediment carried over by the steam depositing on the blades. This is a rare occurrence. Remedy, correct boiler conditions. Cause (b), steam strainer stopped. Remedy, clean the strainer.

5. Machine gradually running out of balance. Cases of this kind have occurred where acid properties of the steam have consumed the balance weights placed in exposed positions.

6. Vibration occurring at intervals with no water trouble—vibration worse at full load or when running non-condensing. Cause, expansion of piping pulling machine out of line. Remedy, firm anchoring of the pipe line and installation of flexible joints.

7. Continual good operation with sudden vibration and stopping of machine with stripping of blades.

Cause, mud or sediment collecting in a body and then coming over into the blades in a large mass.

8. Bad regulation of a steady and continual kind in machines equipped with a steam pilot valve or unbalanced valve. This has been occasioned in some instances by using lime water in the boiler, causing a deposit from the steam of a sticky sediment. Lubrication with good-grade cylinder oil, together with proper cleaning at regular intervals, will successfully meet this condition.

9. Violent vibration, usually accompanied by heating of the shaft just after fitting the packing rings or within a day's time of such work. Cause, packing rings fitted so tight so as to bind the shaft. The action sometimes occurs several hours after the rings are fitted. Remedy, proper adjustment of the packing rings.

10. General heating of the bearings, unstable oil pressure; cause, steam leaking into the bearings and there condensing. Remedy, proper shaft packing and steam deflectors.

11. Injury to machine due to closure of exhaust valve; failure of vacuum, together with stoppage at relief valve; water entering through exhaust steam passage; excessive steam pressure. These and similar troubles are not necessarily characteristic of steam turbines and therefore are not considered as requiring discussion.

Leaks—Their Causes and Remedies

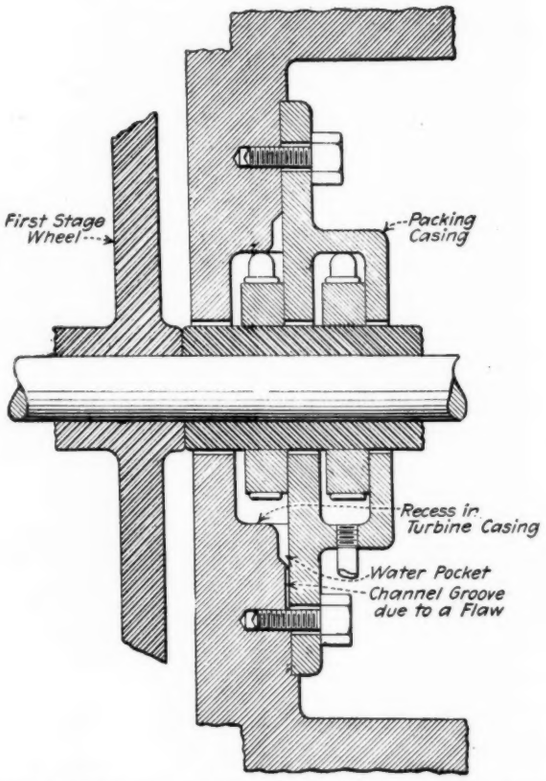
Steam leaks spoil the good appearance of an installation and to some extent represent waste of energy. Vacuum leaks are a direct menace to economical operation. Such things are small in themselves, but often time-consuming to locate and difficult to remedy.

Leaks in pipe lines are well understood, and except in cases of bad vibration or undue pipe strains there is not usually much trouble in stopping them after they are located. Pipe threads that are well cut with sharp tools hold satisfactorily when plastered with a composition such as white lead, cylinder oil and graphite, or red lead and cylinder oil, or some other "dope" that will act as a filler without corroding the threads and making them difficult to unscrew. Corrosive "dopes" such as litharge and red lead should never be used by conscientious engineers if the job is to be dismantled for repair work or inspection. Shellac and graphite, while not corrosive, will stick pipe threads so tight as to make it impossible to take them apart. Leaky valves and unions can be remedied by a little attention or by purchasing fittings that are well suited to the conditions encountered.

Leaks which often give trouble occur in ground joints. These joints are found in a turbine casing, packing casings, etc., where accurate dimensions are necessary and the thickness of the gasket would make such a difference in some dimensions as to cause trouble. Such a joint will sometimes hold when properly aligned and bolted, but it is generally necessary to apply some soft "dope" to act as a filler. The usual method is to use powdered graphite and oil.

Another way of making up such a joint is to place a heavy linen thread soaked in linseed oil along the joint and squeeze this together with a bolt pressure in the same way as a gasket. Both of the foregoing methods have the advantage of making the joint easy to clean when it is taken apart. For this purpose other soft dopes, such as white lead, powdered graphite and double-boiled linseed oil, have the same characteristic as graphite and oil.

When the surfaces are roughly machined and it is difficult to make such a joint hold, the best filler of all, in the writer's opinion, is shellac and powdered graphite, properly applied. The surfaces must be well cleaned and well cooled. This filler should be applied on both surfaces with a paint brush. After bolting together some of the shellac squeezes out. When the joint has become heated, the bolts should again be



JOINT THAT WAS RENDERED TIGHT WITH RED LEAD

tightened, as the consistency of the shellac changes considerably on the application of heat. This filler will be found a good remedy for nearly all bad cases encountered. See that no oil is on the surface before applying the filler. A thin paper gasket can be used if all else fails. If it is necessary to use a corrosive dope, red lead and litharge mixed with glycerine will stop the leak but will make dismantling a tedious process. Such a step appears necessary in one case out of a thousand, and the trouble could probably be solved in some other manner if the situation were well studied.

The most difficult type of ground joint is one in which the bolted element has insufficient surface or is channeled through the surface and must hold water as well as steam. A joint of this kind is recalled which was, in addition, subject to a small vibration. This could be made to hold tight for a while, but the vibration and water together would cause a leak in a short time. The joint held best with shellac and graphite and a paper gasket. It was made to hold tight by placing some powdered red lead in the cavity, which filled with water (see sketch). When the joint began to leak after being made up in this manner, the red lead was drawn into the channel and soon caused a plug which permanently eliminated the trouble.

Refrigeration Study Course—XVI
Ammonia Piping Calculations

By H. J. MACINTIRE
Professor of Mechanical Engineering, University of Idaho

THE expansion piping of a refrigerating system has its counterpart in the boilers of the steam plant. The boilers absorb heat from the hot gases produced by the combustion of the fuel. Whereas with a single boiler the fireman has a ready means of telling about the output, yet in a battery of boilers there is no ready means—except possibly by checking up the coal burned, combined with the flue temperature and the CO_2 analysis—of telling whether one or more boilers are not loafing. Of course there is the steam meter, which gives immediately the response of any boiler to the action of draft and stoking by registering the steam output in pounds per unit of time.

In like manner the expansion piping or refrigerating coils may be "laying down" on the job, and it is even harder to tell just when this is taking place, except that perhaps results are not being obtained. The operator may be holding the suction pressure right, the condenser and all the high pressure side may be apparently in good shape, but the ammonia disappears from the receiver and the temperatures are not maintained. The trouble in these cases is that for some reason or other the ammonia is not being evaporated as it should. It is the boiling of *liquid ammonia at the proper pressure* that gives useful refrigeration. The improper pressure, the presence of oil or scale or water in the inside of the pipe and scale and ice on the outside decrease the ability of the expansion piping to function, and the result is reduced capacity—sometimes very much reduced capacity. With no flow meter the operator may not readily check the several parts of the system. If results are not obtained about the only course is to check over the possibilities for trouble and do such overhauling as seems necessary and desirable.

Plenty of Cooling Surface Allowed

As regards the possible demand on the refrigerating pipes all refrigerating men know that there are the so-called *live loads* and the *leakages*. They vary with each design and location. These embrace the electric lights and the animal heat of the workmen, the mechanical equivalent of heat of the fans or other machinery, the chemical heat of decay, the sensible heat and latent heats (if goods are frozen) of the new goods brought into storage, the liquefaction and freezing of steam given off by the goods (as in the chill room of a packing house) and finally the leakage of heat from the outside atmosphere, which is, of course, nearly always at a temperature considerably above the temperature carried in the refrigerated rooms.

With these varied conditions of operation—of refrigerating load and of heat transmission per square foot of pipe surface—it is naturally difficult to design the expansion piping with economy. The main consideration on the part of most engineers is to get enough surface to be sure to carry the load readily *under any and all conditions of operation*. The tendency has been to play safe, and to be sure that plenty of pipe surface is provided so that after four or five years of indifferent care and attention the machine may still give the contract load. The writer recollects the question asked by the chief engineer of a large refrigerating machine company as to the advisability of using a certain ratio of pipe surfaces, who said, "Are you sure that you can get full capacity of ice from that ice tank after the pipes are fouled by the accumulation of four or five years of oil and scale?" This is a wrong idea and time will see a certain amount of change. The refrigerating machine and piping will be sold with the understanding that these will be maintained in an efficient operating condition. It will be remembered how heavy the copper used to be in electrical machinery, and how steam turbines had better steam economy at 25 per cent overload than at full capacity. The reason for these cases was that the designers were not sure of their machines when operating under the industrial conditions in the field.

The reason for emphasizing so particularly this matter of expansion piping is to call the attention of the reader to the difficulties in the way of the engineer who is planning a new system, and also to make clear the reason for the great variation in the amount of piping one notices from time to time. Under good operating conditions there is no question but that relatively small surfaces may be used, but otherwise there must be sufficient allowance for the decrease in unit output.

The Purpose of Agitation

Still another factor of importance in all heat exchange surfaces is that of the agitation of the surrounding fluid. The best insulating material is "still" air. In refrigeration, in steam boilers and steam condensers, there seems to be a tendency for the adhesion of surrounding air or gas and the formation of an air film that sticks to the surface and greatly increases the resistance to passage of heat through the walls of the pipes or tubes. Anything that may be done to "scrape" off this film by creating a velocity of flow to the medium will increase the coefficient of heat conduction or the capacity of the piping. This is true in the case of a radiator, a bunker coil, an ice making tank, or a cooling tower.

Expansion piping is also allowed to become covered with frost. Some engineers believe that as the diameter increases with an addition of frost the increased surface will make up for the decreased rate of heat by conduction. The reader has only to make a test to get capacity under these conditions of operation to see the fallacy of such an idea. Frost must be removed, either by scraping or by the usual methods of defrosting. One method used with success is to allow brine to trickle down the pipes, arranged as wall piping in stands; this brine will keep the surfaces wetted and at the same time will prevent the accumulation of frost. Whereas the coefficient of conduction is increased, and the necessary amount of piping is proportionally decreased, the extra labor involved in attending to the brine has prevented its general use.

As an example of the method to be used take the example of a cold storage room having walls of 2,200 sq.ft. of surface, and with a leakage coefficient (K) = 0.07 B.t.u. The storage room is designed for 34 deg. F. and for an average of 70 deg. F. outside. The live load consists of 50,000 lb. per day of goods at 65 deg. F. and 0.8 B.t.u. specific heat, and 900 B.t.u. per hr. for 8 hr. (the heat equivalent of two workmen and the lights used). Find the piping required for 24-hour operation.

Leakage loss = $2200 \times 0.07 \times (70 - 34)$ = ... 5,544 B.t.u. per hr.

Average goods load = $\frac{50,000}{24} \times 0.8 \times (65 - 34)$ = ... 51,700 B.t.u. per hr.

Average mechanical load = $\frac{900 \times 8}{24}$ = ... 300 B.t.u per hr.

Air leaks during loading (estimated) = ... 10,000 B.t.u. per hr.

67,544 B.t.u. per hr.

Area piping is equal to $\frac{67,544}{2 \times 20}$ = 1,690 sq.ft. = $1,690 \times 1.6 = 2,704$ lin. ft. 2 in. pipe.

In the problem an estimate has to be made of the loss due to opening the cold storage doors. This amount depends on the personal equation and whether anti-room doors are used. The bringing in of a large amount of relatively hot goods would raise the room temperature, but this point has been neglected as it is assumed that 34 deg. F. is obtained at the end of the 24 hr. Also a value of $K = 2$ has been taken for direct expansion and a temperature difference on the two sides of the pipes of 34 and 14 or 20 deg. F. The calculations do not account for the condensation and freezing of water vapor on the pipes, but such figures should be relatively small. The problem is given to show the factors entering into a calculation, and the results reached. The leakage through the walls may be arrived at by a method similar to that given in the article on "Insulation"* for the type of construction used in the individual case.

The Liquid Line

The liquid line seldom gives trouble, and yet there are a few points about it which are worthy of consideration. The action (as regards the flow of the liquid ammonia from the receiver to the expansion valve) is the same as the flow of water from the air chamber of a pump to the flow nozzle. But for proper regulation the velocity of flow must be nominal.

In nearly every case it does not much matter what drop of pressure there is before reaching the expansion valve providing there is no tendency for vaporization to occur in the pipe due to temperature rise of the liquid ammonia and too great a pressure drop. With a condenser pressure of 150 lb. it is possible to raise the liquid a height of 540 ft. (much greater than water could be raised under the same pressure). It is possible to locate the expansion valve in any part of the usual type of building unless the friction loss in the pipes is excessive.

As a rule the velocity permitted in the ammonia feed line is from 6 to 10 ft. per sec. Knowing the tonnage required the number of pounds of ammonia needed may be calculated. The volume of ammonia is then found by referring to Table I (which gives the weight of one cubic foot) by calculating the reciprocal of the value given. If the volume in cubic inches of the liquid passing any cross section per second is known, then divide by 72 to 120 (the velocity in inches per second). The answer will be the area of the pipe required.

*See article No. 7 of this "Study Course" in *Power* of April 20, 1920, p. 630.

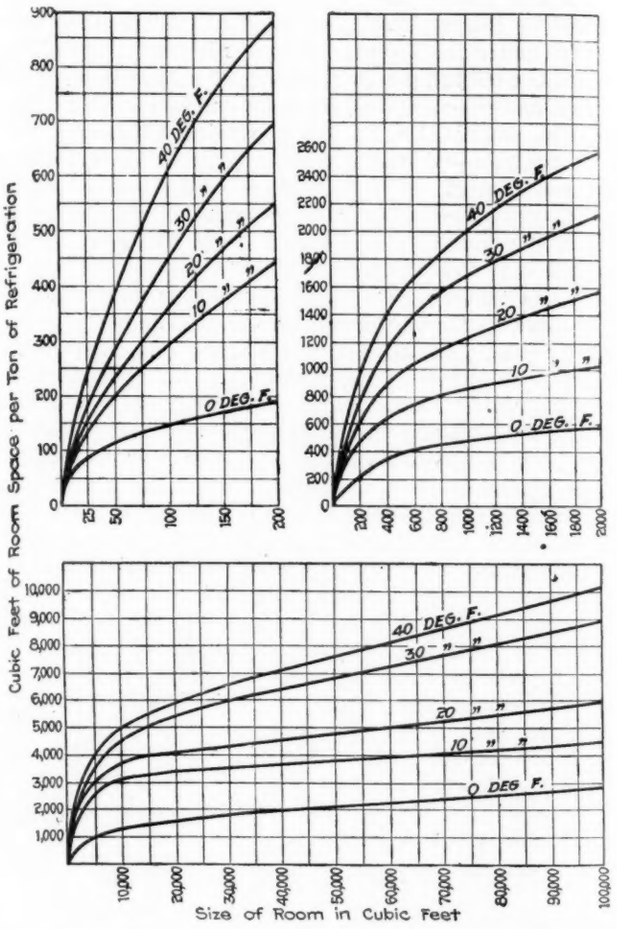
Values of coefficient of conduction "K" in B.t.u. per square foot per degree difference of temperature per hour:

Freezing Tanks

Old style feed, 12 to 15 B.t.u.
Flooded, 20 to 30 B.t.u.

Ammonia Condensers

Submerged, 30 to 40 B.t.u., old style [obsolete].
Atmospheric, 60 to 65 B.t.u.
Flooded, 140 B.t.u., bleeder type, 125 to 150 B.t.u.



VOLUME OF COLD STORAGE SPACE PER TON REFRIGERATION FOR VARIOUS SIZES OF BUILDINGS AND VARIOUS TEMPERATURES

NOTE: Numerous claims for better results are given for the "flooded" condenser but these are disputed.

Bandalot Coolers

(Counter = flow atmospheric)

Milk coolers, 75 B.t.u.
Cream coolers, 60 B.t.u.
Oil coolers, 10 B.t.u.

Brine Coolers

Shell and tube, 90 to 100 B.t.u.

Cooling Coils

Brine to unagitated air, 2 to 2¼ B.t.u.; direct expansion to unagitated air, 1½ to 2 B.t.u.

One inch thickness of ice will reduce the coefficient of heat conduction to 75 to 80 per cent of the values above.

The length of direct expansion piping which may be controlled by an expansion valve is limited to its ability

to free itself of the ammonia gas that is boiled out. In general it may be said that the practical maximum which may be used is:

1100 ft. of 1 in. pipe
1300 ft. of 1¼ in. pipe
1600 ft. of 1½ in. pipe
1900 ft. of 2 in. pipe

With brine pipes the amount of feet of pipe per coil is independent of the size of the pipe, and varies from 100 to 400 ft., depending on operating conditions.

TABLE I. WEIGHT OF LIQUID AMMONIA PER CUBIC FOOT

Temperature Deg. F.	Pounds per Cubic Foot	Temperature Deg. F.	Pounds Per Cubic Foot
85	37.10	50	38.81
80	37.35	45	39.04
75	37.60	40	39.27
70	37.85	35	39.50
65	38.09	30	39.72
60	38.33	25	39.95
55	38.57	20	40.17

Table II will be found convenient for calculations or for checking. Various room temperatures and boiling temperatures of the ammonia are used, giving a variety of pipe lengths per ton of refrigeration. As a general rule (except for short seasonal operation) it is wiser to have high suction pressure and relatively high piping ratios; in other words, an economical operation rather than a low first cost. In Table II the sizes of pipe considered are 1¼ and 2 in., but the brine pipe is figured for 1¼ in. pipe only, whereas the direct expansion (d.e.) is figured for both sizes. Should it be desired to find the length of pipe for some other size, say 2 in. brine, divide the length of pipe as given in the table by the ratio of the external areas of the two pipes. For example, should it be desired to find the length of 2 in. pipe per ton for a room to be held at 20 deg. F. and with a suction pressure of 10 lb., gage pressure, then taking (see Table II) the value 540 ft. and divide by $\frac{2.3}{1.6}$ (the ratio of the external surfaces) and the answer is 378 ft. of 2-in. brine pipe.

As a convenience curves are added. This set of curves is only useful for approximate work and for preliminary estimates. It is possible, however, to get fairly good results from them, provided the conditions found in the particular cases are not abnormal.

TABLE II. LINEAL FEET OF PIPE PER TON OF REFRIGERATION TO COOL AIR

This table is based on a coefficient of heat transmission (K) of 2.5. If any other value of K is desired multiply by 2.5 and divide by value preferred. If no frost accumulates on pipe multiply lineal feet by 0.6

Suction pressure, lb.		45	40	35	30	27	25	22	19	15	12	10	7	4.7	1.4	—2.4
Temp. ammonia, deg. F.		30	26	22	17	14	12	8	4	0	—5	—8	—13	—18	—25	— 35
Temp. brine, deg. F.		38	34	30	25	22	20	16	12	8	3	0	- 5	—10	—19	— 30
	Kind of Pipe															
Room Temperature 65 deg. F.	2 in. d.e.	220	198	179	160	151	145	135	126	119	110	106	99	93	86	77
	1¼ in. d.e.	314	282	256	229	216	208	193	180	170	157	151	141	133	123	110
	1¼ in. br.	400	349	309	270	252	240	221	204	190	178	167	155	144	129	114
Room Temperature 60 deg. F.	2 in. d.e.	257	227	203	179	168	161	148	138	129	119	114	106	99	91	81
	1¼ in. d.e.	368	324	290	256	239	229	212	197	184	170	162	151	141	130	116
	1¼ in. br.	491	416	360	309	285	270	246	225	208	190	180	167	155	137	120
Room Temperature 55 deg. F.	2 in. d.e.	308	266	234	203	188	179	164	151	140	129	122	113	106	96	86
	1¼ in. d.e.	440	380	335	290	269	256	244	216	200	184	175	163	152	137	123
	1¼ in. br.	635	515	433	360	328	309	277	251	230	208	197	180	167	146	127
Room temperature 50 deg. F.	2 in. d.e.	385	321	275	234	214	203	184	168	154	140	133	122	114	103	91
	1¼ in. d.e.	550	459	393	337	306	290	264	240	220	200	193	175	163	147	130
	1¼ in. br.	900	675	540	432	386	360	318	284	258	230	216	197	180	157	135
Room temperature 45 deg. F.	2 in. d.e.	514	406	335	275	249	234	208	188	171	154	145	133	123	110	96
	1¼ in. d.e.	735	580	478	393	356	334	297	269	244	220	207	190	176	157	137
	1¼ in. br.	1540	982	720	540	470	432	373	327	292	258	240	216	197	169	144
Room temperature 40 deg. F.	2 in. d.e.	770	550	428	335	297	275	241	214	193	171	161	145	133	119	103
	1¼ in. d.e.	1110	785	612	478	425	393	344	306	276	244	232	207	190	170	147
	1¼ in. br.	5400	1800	1080	780	600	540	450	386	338	292	270	240	216	184	154
Room temperature 35 deg. F.	2 in. d.e.	1540	856	592	427	366	334	286	248	220	192	179	160	145	129	110
	1¼ in. d.e.	2220	1220	845	610	523	477	409	355	314	274	256	229	207	184	157
	1¼ in. br.			2160	1080	830	720	569	470	400	337	308	270	240	200	166
Room temperature 30 deg. F.	2 in. d.e.		1925	962	592	481	427	350	297	256	220	202	179	160	140	119
	1¼ in. d.e.				845	688	610	500	424	366	314	288	256	229	200	170
	1¼ in. br.				2160	1350	1080	772	600	490	400	360	308	270	220	180
Room temperature 25 deg. F.	2 in. d.e.			2566	962	700	592	452	367	308	256	233	202	179	154	129
	1¼ in. d.e.				1375	1001	846	645	525	440	366	233	288	256	220	185
	1¼ in. br.						2160	1200	830	636	410	432	360	308	246	196
Room temperature 20 deg. F.	2 in. d.e.				2566	1283	962	642	482	385	308	275	233	202	171	140
	1¼ in. d.e.						1375	917	689	550	440	393	333	289	244	200
	1¼ in. br.							2700	1350	900	636	540	432	360	277	216
Room temperature 15 deg. F.	2 in. d.e.					7700	2566	1100	700	514	385	334	275	233	193	154
	1¼ in. d.e.								1000	734	550	477	293	333	276	220
	1¼ in. br.								3600	1543	900	520	540	432	318	240
Room temperature 0 deg. F.	2 in. d.e.									7700	1540	962	592	527	308	220
	1¼ in. d.e.											1375	846	754	441	315
	1¼ in. br.												2160	1080	569	360
Room temperature —10 deg. F.	2 in. d.e.												2570	962	514	308
	1¼ in. d.e.													1375	735	441
	1¼ in. br.														1200	540

d.e. means direct expansion
br. means brine
The values for piping above are for natural draft circulation of air. If forced circulation, multiply by 0.5 to 0.6.

Alaska Coal for Navy

The Secretary of the Interior has returned from his trip to Alaska, fully convinced that it has the coal necessary for its own industries and soon will be in a position to supply the Navy in the Pacific with a coal the equal of Pocahontas. While in Alaska, Secretary Payne ordered the construction of a washing plant at the Eska mine which will greatly improve the low grade coal.

The Navy coal will come from the Chickaloon mine. This property, which is on a branch of the Alaska railroad thirty-seven miles from the main line, also was visited by Secretary Payne. He reports that no less than 400,000 tons of coal are exposed. Just at present the future of that particular mine is somewhat in doubt, due to the faulting of the vein.

Secretary Payne expects to have a committee actively at work in the very near future studying ways and means of stimulating all industries in Alaska.

W. S. Murray—Father of the Super-Power Plan

The super-power plan will affect the operation of industries and railroads in the region extending from Boston to Washington and inland from the coast about 150 miles. By future development of water power, and the location of large steam-driven electric stations at tidewater and at points near the mouth of mines it is estimated that the present power requirement could be served by one-third of the present power generating capacity. In other words, this means that the load factor now averaging not greater that 15 per cent will be lifted to nearly 50 per cent. It is of national importance also that by such a coordinated power arrangement not less than 30,000,000 tons of coal, the equivalent of $150,000,000, will be saved annually, besides decreasing in almost equal amount the annual expense of maintaining the inadequate power machinery now in operation.

GENERAL economic conditions resulting from the war have forcibly drawn the attention of engineers to the necessity of a careful study of our power problems to the end that our former wasteful methods might be replaced by a more efficient generation, transmission and use of electricity and, in the final analysis, effect a substantial conservation of our diminishing fuel supply. In such a study the individual plant must necessarily be subordinated to the problem as a whole. During the last few months this subject has attained added importance in view of the constantly increasing demand for power and the rising price of coal. The matter had been discussed sporadically but it awaited someone to offer concrete data as to possible savings and a definite plan of procedure. Consequently when W. S. Murray, consulting engineer of New York City, came forward with his outline of a Super Power System destined to eliminate the economic waste in our present power system, national interest was immediately aroused and Congress in its Sundry Civil Bill made provision for an appropriation of $125,000 to carry on an investigation of the plan, make surveys, etc.

W. S. MURRAY
Chairman of Super Power Committee

In order to properly carry out the multitudinous details of the investigation the Super Power Committee was formed. It was natural that Mr. Murray should be selected as its head and he was appointed by the Secretary of the Interior. There was needed broad vision, enthusiasm and energy. Mr. Murray possesses these qualifications, and has the advantage of a number of years of study on this project. His work in the past is sufficient evidence of his ability to do things on the super scale.

From the time when he completed his electrical engineering studies at the Lehigh University until today Mr. Murray has been doing and planning work on a large scale. For seven years following his graduation he was associated with the Westinghouse Electric & Manufacturing Co. in the departments of manufacturing, engineering and construction. Here he received a thorough practical training. He severed his connections with this company and opened a consulting engineering practice in Boston, where he remained for four years. At the end of that period he accepted the position of chief electrical engineer of the New York, New Haven & Hartford R.R. in full charge of electrical engineering and construction details of the New Haven electrification. He successfully completed this tremendous task, costing the New Haven R.R. $25,000,000, and a short time later was made consulting engineer in charge of all features of electrical operation.

Mr. Murray has organized his engineering force into three departments of investigation: (1) Railways, (2) Industries and (3) Power and Transmission. He has appointed as the respective heads of these departments, Cary T. Hutchinson, Henry W. Butler and L. E. Imlay. Henry Flood, Jr., has been appointed engineer-secretary.

In discussing the progress of the Super Power Survey he said that Mr. Flood, engineer-secretary, had sent out 450 letters to the Government and Public Service Commissioners and to Executives of Railway and Central Stations in the States which the Super Power Zone includes and their instant and favorable response gave indication of the interest and desire to help in every possible way to furnish the necessary data.

Mr. Murray is the author of many papers on electrical subjects which have been read before numerous engineering societies.

He still finds time to take an active interest in the American Institute of Electrical Engineers, of which he was vice-president from 1913 to 1914. He is also a member of the Bankers Club, the Engineers Club of New York and the Graduates' Club of New Haven.

Organization and Plans of Super-Power Committee

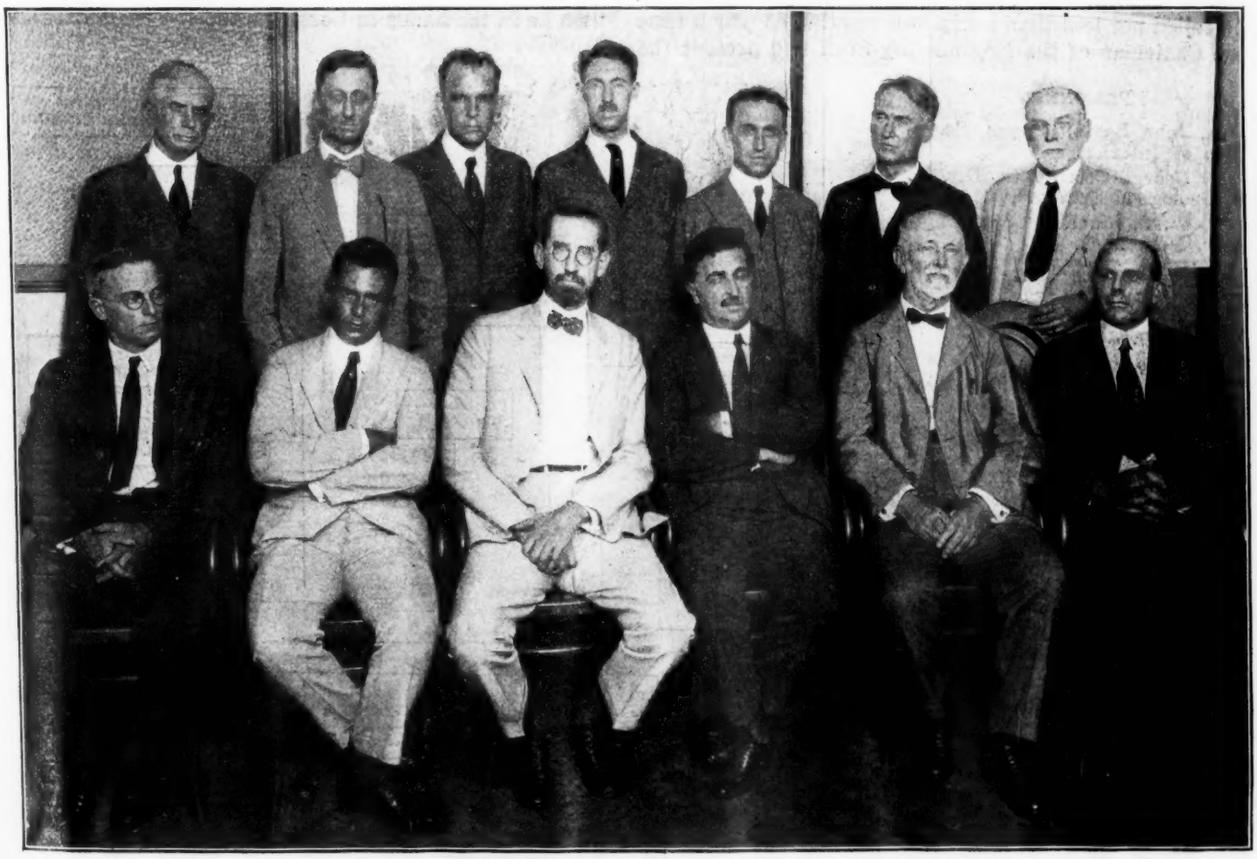
THE United States Government has recognized the appeal made by a committee representing the engineers of this country who appeared before the Appropriations Committee of the House of Representatives in April to present the case of the Super-Power System, and both branches of Congress have now approved the Super-Power Survey for the zone on the North Atlantic seaboard between Boston and Washington and inland from the coast averaging 150 miles and have granted an appropriation in the amount of $125,000 with which to carry on the work.

Mr. Murray in a recent interview said that in the area between Boston and Washington and inland from the coast 150 miles, which is less than 5 per cent of that of the United States, there is installed a machine capacity aggregating 17,000,000 horsepower; 10,000,000 of this is required to run the industries; 7,000,000 is required to operate the railroads.

The part, therefore, that the Government is playing in this matter is only to finance an administrative and engineering force to show clearly what these wastes are; and this force has been organized and is known as the Super-Power Survey, with headquarters at 709 Sixth Avenue, New York City.

The diagrams here shown give the form of organization by which the power survey will be conducted. As the object of the investigation and report is necessarily divided into two principal features—(a) an allocation of and the amount of wastes in labor, fuel, and other materials as at present applied to the railways and industries in the zone, and (b) the design of a regional system by means of which these wastes will be eliminated, it seemed of special importance that the investigation should be divided into three departments, namely, power and transmission, railways, and industries. To that end three departments were created and a division chief appointed to head each, with an engineer-secretary assigned to the duty of collaborating with these division chiefs in the collection of field data and preparing the data as nearly as possible for report text. The services of the Chief Hydraulic Engineer of the United States Geological Survey and of the Chief Mechanical Engineer of the Bureau of Mines will also be contributed in part to the engineering staff of the Super-Power Survey.

It was desirable to obtain the counsel of men who would be representative of power producers and power consumers and of the people as a whole representing a national power policy. Therefore an advisory board was appointed of men representative of the above classes, and to that end the Secretary of the Interior officially invited to membership on such a board men who would be representative of New England railroads, New York railroads, engineering, technical publicity, the National Electric Light Association, the American Electric Railway Association, the American Railway



MEN WHO WILL DIRECT THE SUPER-POWER SURVEY

Upper row from left to right: Lorin E. Imlay, C. T. Hutchinson, Henry W. Butler, Harold Goodwin, Jr., L. A. Whitsit, N. C. McPherson, James H. McGraw. Lower row: C. H. Pierce, Henry Flood, Jr., W. S. Murray, Otis Smith, Prof. L. P. Breckenridge, N. C. Grover

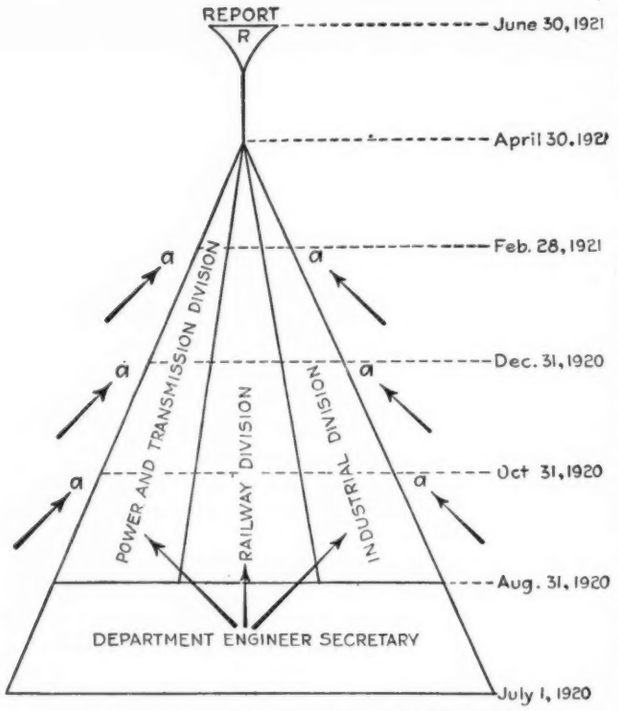


FIG. 1. FUNCTIONING OF ORGANIZATION

Association, and the National Industrial Conference Board.

Meetings of the Advisory Board, which will be attended also by the Director of the United States Geological Survey and the Chairman of the Engineering Staff, will be called not less than every two months, at which time the Chairman of the Engineering Staff will present the progress of the work during the two previous months and the proposed procedure during the succeeding two months. In such manner the engineering staff will constantly have the advantage and value of the counsel of such an advisory board. Prof. L. P. Breckenridge, of Yale University, has consented to serve as chairman of that board.

Referring again to the diagrams: Fig. 2 gives a fair idea of the Super-Power organization, as above described, for the conduct of the power survey; Fig. 1 is an attempt to show the functioning of the organization as shown in Fig. 2. On these diagrams "F" is a focus toward which the entire organization will be working, that is, as of May, 1921, when all fundamental data necessary to the compilation of the report, with maps and diagrams, must have been collected. The triangular divisions are the power and transmission, railway, and industrial departments of investigation. The base section of the triangle represents the department of the engineer-secretary, and shows, by arrows, his collaborating arrangement with the three division chiefs in the preparation of report text. The arrows indicated by the letter "a" indicate the effect of advice from the advisory board in shaping the report and bringing it to a focus, and the horizontal zones throughout the total triangle indicate the bi-monthly meetings of the advisory board with the engineering staff regarding past progress and future procedure. As indicated by this diagram, the time between April 30 and June 30 will be devoted to the final preparation of report text with its accompanying maps and diagrams for presentation June 30, 1921, when the Congressional appropriation terminates the matter will then be in the hands of Congress and the committee will dissolve.

PERSONNEL

A. John Barton Payne, Secretary of Interior.

B. George Otis Smith, Dir. U. S. Geological Survey.

C. W. S. Murray, Cons. Engineer, New York.

D. E. G. Buckland, Vice-Pres. N. Y., N. H. & H. R.R.

E. A. T. Hardin, Vice-Pres. N. Y. Central R.R.

F. Appointment not made.

G. John H. Pardee, Pres. Am. Elec. Ry. Assn.

H. L. P. Breckenridge, Head Dept. Mech. Eng., Yale.

I. J. H. McGraw, Pres. McGraw-Hill Pub. Co.

J. Appointment not made.

K. Magnus W. Alexander, Mgr. Dir. Nat'l Industrial Conference Board.

L. Henry Flood, Jr., Cons. Engineer, Pittsburgh.

M. L. E. Imlay, Cons. Engineer, Niagara Falls.

N. Cary T. Hutchinson, Cons. Engineer, New York.

O. Henry W. Butler, Cons. Engineer, New York.

P. N. C. Grover, Chief Hydraulic Eng. U. S. Geological Survey.

Q. O. P. Hood, Chief Mech. Engineer, U. S. Bureau Mines.

R. J. J. Madigan, Chief Clerk U. S. Geological Survey.

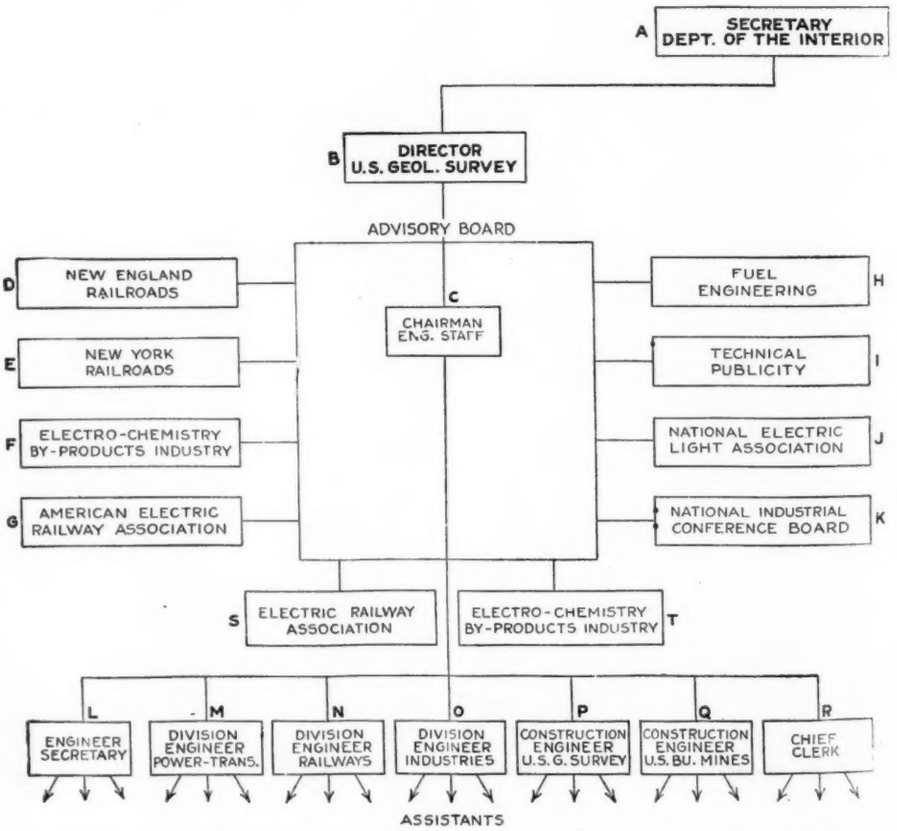


FIG. 2. CHART SHOWING PERSONNEL OF SUPERPOWER COMMITTEE

EDITORIALS

From War Service to Industrial Pursuits

DURING the war many industrial centers sprung into existence practically overnight, to meet emergencies of various kinds. In most all of these were power plants, many of which represented no small achievements in modern engineering, not alone from the standpoint of the short period and adverse circumstances under which these plants were built but also in their design. However, many of these plants have already been dismantled or are passing out of existence, except for what may be salvaged, and must be charged up to the necessary cost of carrying on the world's greatest war to a successful conclusion for ourselves and our allies. There are nevertheless numerous industrial power plants, that were the direct outcome of the war, still in existence and are serving peace time industries. An example of one of these plants is that of the Merchants Shipbuilding Corporation at Bristol, Pa., described in this issue.

As a result of the conditions encountered when the power plant was built it was impossible to remove an existing plant used to supply power to a foundry on part of the site where the shipyard was constructed. This made necessary the building of the new plant around three sides of the old plant. The extremely long steam header—590 feet in length—necessary on account of the distance from the boiler and engine room, is one feature worthy of passing interest in this plant, all the joints of which are butt-welded. The fact that these joints have given satisfactory service, even when made under stress of war, is another testimony of the possibilities of autogenous welding.

A feature in this plant that is somewhat at variance with modern tendencies in air compressor drives is that all seven air compressors are located in the power plant and steam driven, which no doubt when operated condensing as these are can show an overall efficiency comparable to that of a motor-driven compressor. As the author states, "if it had not been possible to locate the compressors in the power house and operate them condensing synchronous motor driven units would no doubt have been installed." Where the power factor is low it would apparently have been better practice to have operated at least one or two of the compressors by synchronous motors, having sufficient capacity to not only drive the machines, but also to correct the power factor to near unity. Such operation would probably not have required any more generator capacity than at the present time and might have made possible a lower water rate for the turbines. That a power factor correcting device can be installed in the form of a static or a synchronous condenser at less cost than a synchronous motor, as stated by the author, is open to question, especially when the synchronous motor is designed to operate at its most economical load; seventy per cent mechanical load and the same per cent reactive component load. These two loads combined will only require the equivalent capacity of one hundred per cent mechanical load.

This point has not been raised to question the engineering judgment of those who designed and built the plant, but rather point out that under conditions not so urgent as those during the stress of war refinements of design may be taken advantage of, that were not warranted in the design of this plant. As the author points out, "Apparatus obtainable, rather than the best combinations of sizes for the load conditions determine the selection." A study of the acceptance test figures given will show, although the equipment was obtained where most convenient, the plant's efficiency compares favorably with those of the same capacity built under more advantageous conditions. One of the most gratifying features is that this plant is to continue to operate as an adjunct to one of America's new industries which is a heritage of the part we played in the world's greatest conflict.

Nationalize the Fuel Supply

A SURE and plentiful supply of fuel is one of the first requisites to national security and well-being, the assurance of which is a proper and legitimate activity for a people in its collective capacity.

With the application to the eternal struggle against the forces of nature of accumulated knowledge and experience and scientific discovery; with the employment of the marvelous tools and machinery at our command; with facilities for handling, storing and distributing which have never been equaled; with uses found for many portions of the product formerly thrown away; with all the economies of aggregation which should result from doing things upon a big scale; a consumer ought to be able to exchange his day's work for more of the commodities of life than ever before. There is no physical reason for the high cost of living.

The grand-scale development in production and exchange of the past half century has not been accompanied on the part of the public, by any intelligent, controlling, directive effort toward over-all efficiency.

The production of the nation's fuel supply can no longer be left to the undirected and ununified discretion of competing individuals, nor its distribution to the erratic machinations of those whose acknowledged aim is to exact profit from rather than to expedite its handling.

The demand is known or ascertainable; the sources of supply are visible and controllable. There should be intelligent authoritative correlation, the one with the other. The means of storing periodical production in excess of current consumption should be applied to smoothing out disparities between contemporaneous supply and demand, and the machinery of distribution should be so organized that the product would proceed systematically from producer to consumer by the cheap-

est route and without reselling, except by the retailer. The eventual price to the consumer should be cost plus a fair profit.

Such a system involves nothing more than the application of principles and methods already in daily use. Any good industrial engineer or manager, given the authority, could put it into operation. It is not utopian nor unduly paternal. It would be simply the organizing, systematizing and correlating by the people, of the processes upon which their sustenance depends; and which, they have very cogent reasons to believe, have gotten beyond the ability or the willingness of individual or corporate enterprise effectively and economically to administer.

The Engineer and the Super-Power System

Before any intelligent solution of a problem can be offered, it is first necessary to be able to allocate to each factor entering into the analysis its correct value. We know there are tremendous wastes going on all over the country in the generation and distribution of power from fuel but the allocation of those wastes, just what their exact values are, are only conjectures or estimates. At the present time it is estimated that three hundred million dollars per year can be saved by a proper system of generation and distribution of power to the industries along the Atlantic seaboard between Washington and Boston and one hundred to one hundred and fifty miles inland but, up to the present time at best this is only an estimate. What is required before any progress can be made toward a solution is facts and this W. S. Murray and his committees composed of eminent engineers have attempted to obtain. This committee is known as the Super-Power Survey, and details of this organization are published elsewhere in this issue.

This committee is peculiar for many reasons. It is one of the few that is to operate under Government direction on engineering work that is composed entirely of engineers. The tremendous economic importance of a correct solution of the power problem in the super-power zone alone, is one that should warrant the hearty co-operation of every American engineer, but the fact that this is an opportunity for the engineers of the country to show that they are well fitted to fill positions of national importance should make the successful carrying out of the work which Mr. Murray has so energetically undertaken, doubly merit their support. Congress has appropriated one hundred and twenty-five thousand dollars to finance this committee to show what the wastes are. If the committee accomplishes this the appropriation will be warranted many times over.

Generally, in such projects as this several years lapse before definite action is taken if at all. But in this case it has been only a matter of months, which is another indication of the influence engineers may exert when they get squarely behind a movement.

This undertaking is not alone of particular interest to those living along the North Atlantic seaboard, but to the entire country. Railway congestions in this district did not alone affect the industries located in this region but practically the entire nation. Consequently, the Super-Power Survey at present under way, merits national support.

Making the Best of What You Have

THESE are active days for power plant men. There are problems of many kinds confronting them. Of these, coal presents one of the most serious. The problem has several corners to it, for not only is it difficult to get the particular kind of coal one wants, but the price of whatever is obtained is sure to make one gasp.

The plant must be kept running. This is the engineer's job. It must be kept running as economically as the best of men can make it run. Combustion is a decidedly complex operation even in its simplest form. But the economical burning of coal unsuited to stoker and furnace in the usual industrial power plant is an operation which requires considerable skill and knowledge. There are thousands of plants the engineers of which are today confronted with this perplexing situation. Obviously the equipment cannot be changed every time another carload or boatload of coal comes in. One must make the best of what one has. But to do so the man in charge must have a through knowledge of the fundamentals of practicable combustion. He who has had the ambition to study it enough to know more than was sufficient to carry him through the exigencies of a moment can now "cash in" with his accumulation of knowledge of the burning of various grades of fuel.

While it is particularly true that in these days every plant calls for individual treatment in the solution of combustion problems, nevertheless this very condition offers opportunity for considerable good to be done by group effort. It at the meetings of the various engineering organizations those having problems would present them for discussion at the meeting, he who was in difficulty would not only be helped out, but he would be the means of enlightening many of his fellows.

There is many a meeting room where an Orsat apparatus is hidden away on some high back shelf, dust laden and with its rubber connecting pieces cracked and dry. There never was a more opportune time to bring that instrument into the light and demonstrate its working before the meeting. Make a real demonstration by connecting it with a few samples of gas brought to the meeting room by those who have the gas collectors.

Rumors again were rife last week to the effect that the President soon will appoint a Fuel Administrator. This was attributed to pressure from the public utilities and from the fact that the Attorney General had not been able to get all those interested in the coal trade together in a fair price conference. While no authentic denial could be obtained either at the White House or the Department of Justice, the improvement in the coal situation tended to cause the rumor to be discredited in many quarters. At this writing, it is expected that the Attorney General shortly will announce a fair price for coal.

The engineer that keeps the instruments for operating the steam equipment of his plant in reliable condition and neglects the electrical is doing only half the job. Frequently it is possible to make large savings by a proper analysis of the electrical requirements but this cannot be done unless the instrument records are reliable.

CORRESPONDENCE

Should the Main Belt Break, What Would the Engine Do?

I have witnessed the effect of the main belt breaking at two plants on two different types of engines. In each case water was to blame for the accident. High water had filled the wheel pit and loosened the belt splices in one case, and in the other a burst water pipe caused the belt to skid and catch in the main hanger housing, tearing down a section of shafting and ripping the belt in two. In both instances the valve gear had been readjusted a short time prior to the accident; otherwise, no doubt the engines would have overspeeded and perhaps wrecked the plants.

In the first case the 24 x 48-in. engine was turning at 60 r.p.m.; the steam valves were of the poppet type, Fig. 1. Previous to my taking charge of the plant a

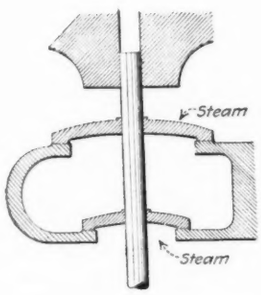


FIG. 1. POPPET VALVE

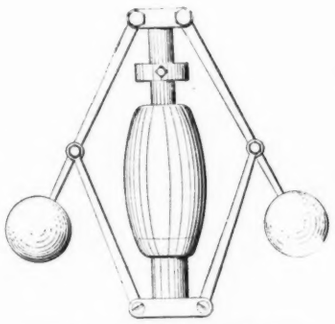


FIG. 2. COLLAR TOO LOW

young man had been operating, and his limited experience had been on Corliss valve gears. "It was perfectly legitimate to allow the steam valves to open not quite the amount of lap," he was informed, "should the governor rise to the high point." So he applied the same principle to the poppet valve, but the poppet valve has no lap.

On taking charge of the plant my thoughts were —Do the safety valves blow at the required point and does the governor shut off steam when at its maximum high position? I found that the safety valves operated as they should, but the second condition was far from satisfactory, as the valves were open fully an eighth of an inch with the governor, Fig. 2, in its maximum high position. This was not enough to overspeed the engine, as the friction load was heavy, but should the main belt break and no attendant be near, a wreck might follow.

On shortening the cutoff gear to just clear the lifting lever, I found that I was robbing the engine of about 80 hp. at full load, but I raised the steam pressure to compensate and so was able to pull through until I could change the governor's levers from *A* to *B* (see

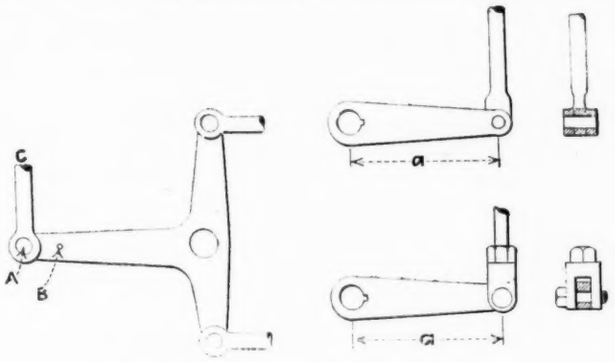


FIG. 3. CHANGED GOVERNOR ARM

Fig. 3). This gave a long cutoff when necessary and no lift of the valves when the governor was at its high point, Fig. 4.

That this change was a wise move was proved when the belt pulled apart from overstrain, lapped about an overhead steam pipe under 100-lb. pressure, pulled it down and finally wound up on the flywheel. While this performance was going on it was impossible to get

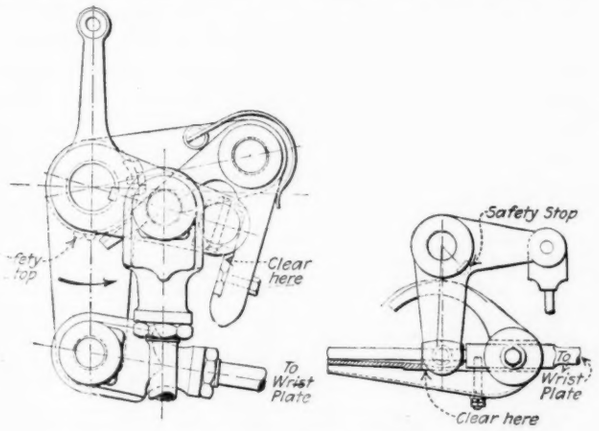


FIG. 4. LATCH BLOCKS SHOULD CLEAR WITH GOVERNOR IN HIGH POSITION

into the engine room, but by looking through a window the crank could be seen turning its sixty turns just as smoothly as though it were still pulling its load.

Had the main belt or the broken steam pipe fouled or damaged the governor, thus causing it to drop to running position, of course there would have been a different story to tell. This governor was geared from the valve-gear shaft and had no safety stop.

The second case was a 16 x 36-in. engine, of the gridiron-valve type, running at 70 r.p.m. It was possible to pull clutches at various points and so reduce the friction load to a minimum. There was no way of increasing or decreasing the speed of this engine except by changing the governor pulley. The speed had been 68, and 70 or 72 r.p.m. was desired, so the vertical stem was shortened a trifle, which allowed a longer cutoff. When I say no way of increasing or diminishing speed, I mean no legitimate way that would still protect the engine from overspeed should the governor have reason to rise to the high point.

By lengthening the cutoff the engine was out of control of the governor on an extremely light load. When the valves were properly set and the cutoffs properly adjusted, the speed was reduced to 68 r.p.m., so a larger pulley was put on the governor and the desired speed, 72 r.p.m., was obtained. Later, when the water pipe burst and soaked the belt, causing it to skid and do much damage, the engine, freed from its load, only increased its speed very slightly.

As in the former case, had the main belt or pieces of the broken shafting hangers wrecked the governor, of course perfect valve adjustment would not have counted.

It is a mistake to allow an engine to open the valve even the amount of lap when the governor is at high point, because the very slightest amount of steam admitted will overspeed the engine on no load, especially if it operates condensing.

If the engine will not carry its load and still release fully when the governor is in its high position change its leverage to get a greater travel of the cutoff gear. I stand in greater fear of a slipping governor belt than of a broken main belt. If the truth were known, probably more engine wrecks are caused by slipping governor belts and valves opening the amount of the lap than by anything else.

New York City. C. W. PETERS.

Still Another Long Run

I read with interest what was published relating to a long run of a steam turbine, in the May 18 issue of *Power*, and also the account of a 126-day run of a water-wheel driven generator, published in the June 29 issue. They have nothing on the reciprocating engine.

We have a 17 and 34 x 42-in. Nordberg tandem-compound Corliss engine direct-connected to a No. 10 Connersville Blower and used for smelter purposes, with about 42 oz. pressure. This engine made practically a continuous run from 3 o'clock p.m., Oct. 22, 1919, when it was shut down for inspection and keying up, until 1 o'clock p.m., Jan. 28, 1920, when it was again shut down for two hours for smelter repairs. The engine was keyed up and put in operation again and ran till March 17.

During the first period the engine was shut down one hour for smelter repairs on the night shift, but there was no inspection or keying up done. This engine has practically continuous work, and I would like to hear from anyone who can beat it. E. H. BEAVERS.

Mapimi, Durango, Mexico.

Conduit Rheostat Used To Handle 1,800 Amperes

When a large generator partly burned out and it was necessary to remove the coils to reinsulate them, the first obstacle encountered was the heating of the coils to soften the insulation so as not to damage the latter when pulling out the former. There was needed about 6 volts to heat the coils, and as there were no rheostats available to handle this current, it was decided to use a 250-volt 500-kw. motor-generator set, located next to the damaged generator. The motor-generator set was driven by an induction motor, therefore there was no chance of regulation from the motor end, nor could the generator be controlled from its own shunt field, because of the low voltage, so it was decided to insert some resistance in the circuit between the two machines as shown.

Conduit being available, and also the easiest to handle, we connected thirteen lengths of ¾-in. end to end and bent it in the shape of a U, so as to have each terminal

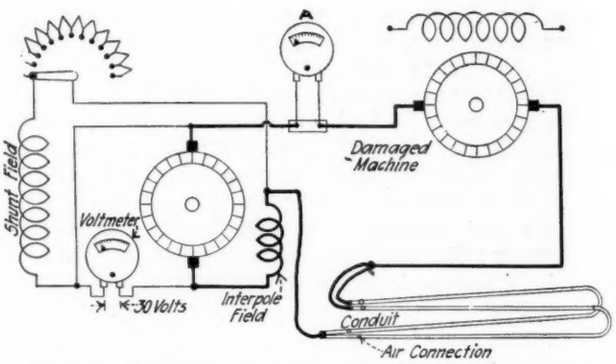


DIAGRAM OF GENERATOR AND RHEOSTAT CONNECTIONS

at the machine. When this was tried out, the voltage of the generator could be reduced to 140 volts, with 1,800 amperes flowing in the circuit, but the conduit in a few minutes became red hot and some of the coupling almost a white heat.

The next move was to use some 1-in. conduit, which we connected in two runs of seven lengths each, and bent them in a U shape. Before they were connected, the thread of each end and the couplings were cleaned. The ends of each loop were flattened and drilled to make the connection. We also drilled and tapped one hole in each loop, to make a connection with an air hose so as to circulate air through the conduit for additional cooling, as shown in the figure. After being bent, all ends of the conduit did not come even, so one end of each loop was bolted together and connected to the generator, while two separate cables from the other two end were run to the damaged generator as in the figure.

Thirty volts were obtained at the generator terminals when supplying 1,800 amperes. This could be controlled very nicely with the shunt rheostat and could carry it indefinitely as long as air was circulated through the conduit. A very interesting feature was discovered when the shunt field was opened. It was found that the generator would deliver about 2,200 amperes at 30 volts. Presumably, the excitation was supplied from the interpoles. A. N. SIMMONS.

Detroit, Mich.

Elevator Worm-Shaft Bushing Worn Caused Sparking at Brushes

The brushes in an elevated motor gave trouble by frequent sparking. Ths motor was the 4-pole consequent-pole type (Fig. 1), having only two exciting coils. The machine had been recently rewound for 240 volts, replacing the original 120-volt winding. It was

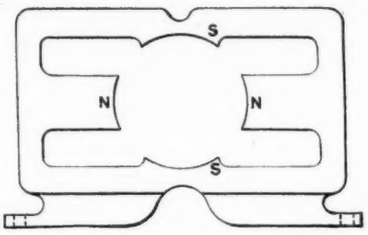


FIG. 1. FOUR-POLE CONSEQUENT-POLE STYLE OF FIELD FRAME

thought that the voltage between the segments was too high and that this was the cause of the sparking. Later developments, however, proved these conclusions to be wrong.

While watching the brushes and commutator after an attempt to stop the sparking, it was noticed that the air gap between the polepiece and the armature changed at different loads or positions of the car. This change did not take place with any regularity, and frequently the car would make several trips before the armature would be drawn to one side near a polepiece having an exciting coil.

We examined the field pole to see if it was loose in the frame, but there was no trouble here; then a side pressure with a lever was applied to the armature shaft

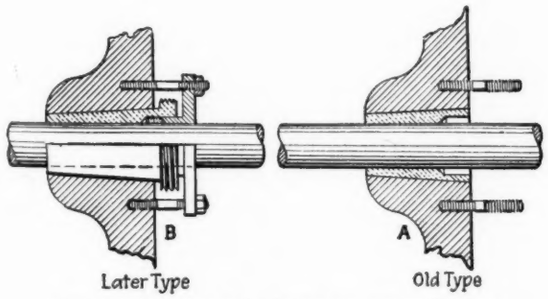


FIG. 2 OLD AND NEW TYPE OF BUSHING

where it was coupled to the elevator worm shaft, and it was found that it could be moved about 0.1 of an inch. Here then was our trouble and it was a serious one too, for this deflection had not only been the cause of sparking, but had caused an armature shaft to break at the coupling at an earlier date. As the brake wheel was at the outer end of the motor shaft, there was nothing to hold the car when the failure occurred at or near the coupling, and only the safety appliances were left to stop the car from falling. Later types have the brake wheel attached directly to the worm shaft. When the armature shaft broke, the car was lightly loaded and the counterweights being heavier than the car and load caused the latter to race in the up motion until sufficient speed was attained to operate the safety.

It was decided to put a new bushing into the gear-case bearing. As this was the only elevator in the building and was used for both passenger and freight service, it was necessary to make the repair as quickly as possible. It was short work to disconnect and move the motor away and pull the coupling from the worm shaft, but when we came to remove the bronze bushing, we were up against it.

This was a Sprague machine and must have been one of the first manufactured, for the bronze bushing only came flush with the casting, as shown at *A*, Fig. 2. Later types of this make have an extension of the bush-

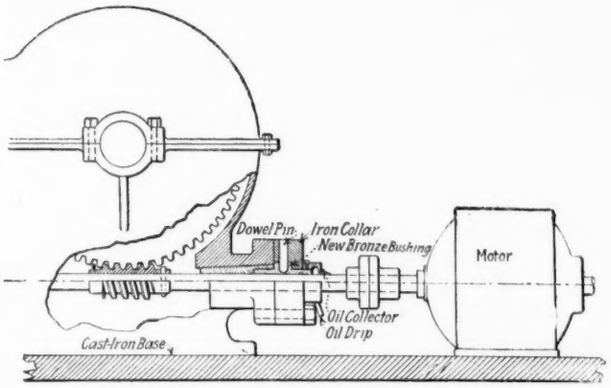


FIG. 3. SECTIONAL VIEW SHOWING HOW DRUM-SHAFT BEARING WAS REPAIRED

ing, on the outside of which is a threaded section and a capstan nut by which the bushing can be readily pulled out as at *B*, Fig. 2. To get the older type of bushing out, it would be necessary to remove the worm shaft and split the bushing or drive it out from the inside of the gear case.

A previous experience made us hesitate about pulling the worm shaft through the worms, it having taken two days to jack one out. The machine was tandem geared, as in Fig. 3, and the bearings, after the bush-

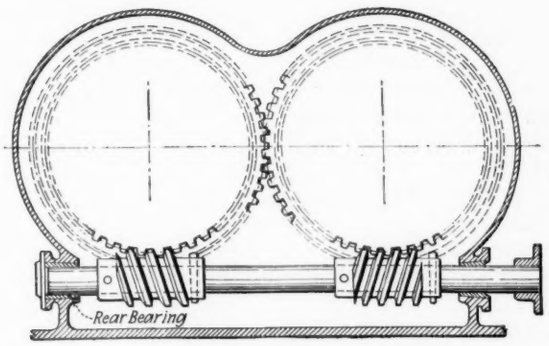


FIG. 4. TANDEM WORM AND SPUR GEAR

ings were removed, were not large enough for the worms to pass through; consequently, the worm shaft could not be removed without pushing it through the worms. It was decided to fit a new bushing into the space formerly left for the packing and extend it out the same length as the bearing of the old bushing. The bore of the space left for packing, having had no wear, would be concentric with the original bearing and would bring the new bushing into position to carry the worm shaft in its original relation with the worm gears.

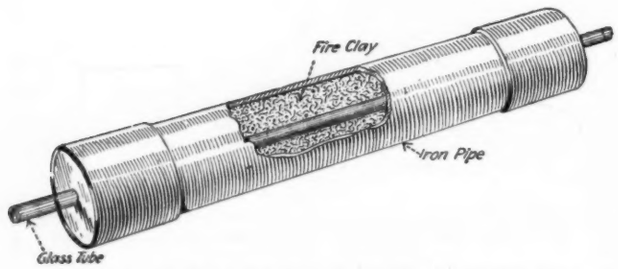
An iron collar was machined and a bronze bushing forced and doweled in, as shown in Fig. 4. No packing was provided for, but an oil-collecting collar, with drip pipe, was supplied instead, as is shown. This repair was completed by having the elevator out of service for two days. It has stopped all brush troubles, runs cool, is safe and satisfactory in all ways.

Washington, D. C. D. ALFRED MANSON.

Home-Made Gas-Sampling Tube

Some months ago, while making various kinds of engineering tests, I had occasion to take snap samples of gas over the fire, and in different passes of several large water-tube boilers.

At first thought the only solution for taking hot gas samples over the fire in the furnace of the boiler seemed



GAS-SAMPLING TUBE MADE OF GLASS TUBE AND PIPE FITTINGS

to be to purchase an expensive high-temperature porcelain tube. It would have taken weeks and perhaps months to secure such a tube, and it would be costly and very delicate for this class of work, so I set about to provide a tube that would answer the purpose.

A 6-ft. length of ¾-in. iron pipe was threaded at each end and fitted with pipe couplings, and a ¾ x ¼-in. pipe bushing was inserted in the outer end of each coupling. A ¼-in. glass tube 6 ft. 4 in. long was slipped through the bushings on the ends of the pipe, and the pipe was fastened in a vertical position. The bushing was screwed out of the upper end of the pipe and the pipe filled with a grout made of fireclay and water. The bushing was then replaced, bringing the glass tube central in the pipe. The improvised tube was then placed in a horizontal position on the top of one of the boilers and allowed to remain there about three days, at which time the moisture was evaporated from the grout.

With this arrangement I was able to secure samples of gas in the furnace of the boiler about six feet above the fire. A. J. MACKENZIE.

Crafton, Pa.

Kept the Engine in Good Condition

Having recently given my main 16 x 18-in. Corliss engine a thorough inspection, I thought it might be of interest to other engineers to know the result. The engine is around twenty-one years old and has been in my charge about seventeen years. For some time we have been rather short of power, particularly in the boiler room, and the little bird that somehow gets to the office of the "Boss" must have been busy, as a request for some indicator diagrams, a somewhat unusual one, too, resulted in my supplying what was desired.

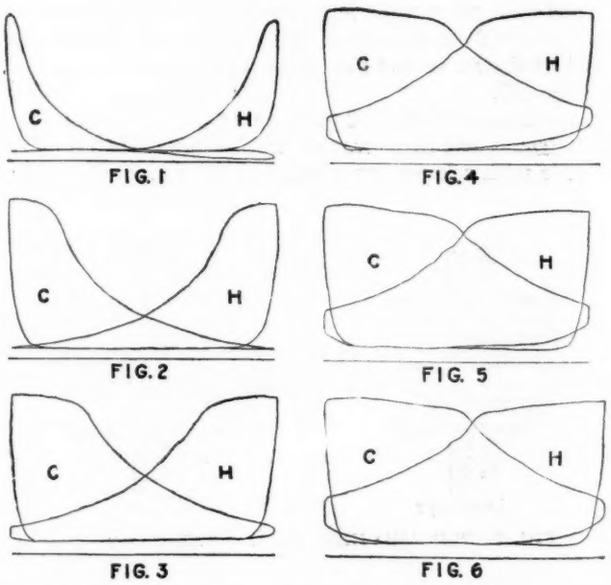
The accompanying diagrams show what was found and that with only a very trifling adjustment. Diagram, Fig. 1, is a friction load only, the 125-kw. generator being belted to the engine. Notice the evenness of the two diagrams. Fig. 2 shows a light load of 400 amperes. Fig. 3 is near the economical capacity, with a load of 690 amperes. Fig. 4 is over the rated load, carrying, as it does, 875 amperes. Figs. 5 and 6 show very much overload, or 900 and 925 amperes respectively. All the diagrams show very even steam distribution and, what is seldom seen, all loads are well balanced.

The engine exhausts into a heating system, and this accounts for the high back pressure. There is a slight indication of leakage, and further testing showed that such existed, but not sufficient to warrant any work being done on either piston or valves.

The cylinder was calipered and showed wear at the head end 0.017 in.; in the middle, 0.007 in., and at the crank end, 0.01 inch.

I have always been an advocate of good cylinder oil, and this examination showed the result of it, the cylinder being a brown, glossy color, also the piston rod and the valves. The inside of the piston was clean, with no sign of crusty matter such as I have seen taken from pistons. The piston was found to be central in the cylinder and all signs showed, what I had claimed, that the engine was in first-class condition.

About seven pints of cylinder oil is used per week of 52½ hours. This is handled by a force-feed lubricator.



LOADS FROM FRICTION TO HEAVY OVERLOADS

A home-made oiling system supplies oil from a tank, supported over the main bearing, to all bearings excepting the outboard bearing, eccentric and wristpin, which are lubricated with grease for the sake of cleanliness and convenience of application. The oil is collected in pans, and a channel in the floor under the crankpin, which drains through a pipe laid in the concrete floor to a pail in a nearby pit, the net consumption of oil being about one gallon per day.

The ascertainable expense for all repairs for the period of twenty-one years, including replacement of parts, is about $250. I think this is very low.

Trenton, N. J. HARRY H. YATES.

INQUIRIES OF GENERAL INTEREST

Gallons Capacity of Cylindrical Tank—What is the formula for estimating the gallons of capacity of a cylindrical tank? M. R.

Where D = the diameter of the tank in inches and L = the length in inches, the complete formula is

$$\textit{Number of U. S. gallons} = D^2 \times 0.7854 \times L \div 2.31,$$

or the shorter form,

$$\textit{Number of U. S. gallons} = D^2 \times L \times 0.0034.$$

Determining Leakage of Piston and Valves—What is the best method of testing for leakage of the piston and valves of a Corliss engine? B. H.

Let steam in one end of the cylinder and open the indicator cock at the other end and leakage of the piston can be detected by escape of steam. By closing the valves and opening both cocks, leakage of the valves can be detected. Leakage of the exhaust valve is shown by steam blowing out of the exhaust pipe when steam is admitted to the cylinder, with the indicator cocks and exhaust valves closed.

Formula for Estimating Heat Value of Coal—How is the heat value of coal estimated from the chemical analysis of the coal? D. A. B.

The heat value of coal may be calculated from its ultimate analysis with a probable error not exceeding 2 per cent, by Dulong's formula:

$$\textit{Heat value in B.t.u. per pound} = 146\ C + 620\left(H\frac{0}{8}\right) + 40\ S,$$

in which C, H, O, and S are respectively the percentages of carbon, hydrogen, oxygen and sulphur shown by the analysis.

Advantage of Riding Cut Off Valve—What is the advantage of a riding cutoff over a single automatic cutoff valve? R. M.

For medium and slow speed engines, it is desirable to have uniform points of release and compression. With a single valve, the points of release and compression must vary with the point of cutoff. With a riding cutoff the main valve determines the lead, point of release and point of exhaust closure and these are constant, as the main valve is operated by a fixed eccentric. The duty of the riding cutoff valve is simply to close the ports in the main valve and effect the point of cutoff, as determined either by hand adjustment or by the governor, depending upon whether the engine is a throttling or an automatic cutoff engine.

Obtaining Sample of Flue Gas Analysis—At what point of a boiler setting should samples of flue gas be taken for CO_2 determination? J. F.

Samples of flue gas are usually taken from the breeching between the boiler and stack, and preferably where the gases are just leaving the boiler. The sampling tube should be made of a small size of pipe with a number of ¼ in. holes drilled in its sides, and extended nearly all the way across the breeching, so the sample of gas collected will represent the average of flue gases discharged to the stack.

Discharge of Steam Jets—What quantity of steam at 100 lb. boiler pressure would be used by a steam jet having four nozzles each ⅛ in. dia. discharging into a boiler ash pit? C. H. T.

The discharge would be given approximately by Napier's rule for flow of steam through orifices when the final absolute pressure is less than 58 per cent of the initial absolute pressure, namely,

$$\textit{Flow in pounds per second} = \textit{absolute initial pressure} \times \textit{area orifice in sq.in.} \div 70$$

Having an initial absolute pressure of 115 lb. per sq. in. and 4 orifices, each ⅛ in. dia. their total area would be ⅛ × ⅛ × 0.7854 × 4 = 0.00307 × 4 = 0.01228 sq. in., and by the formula the discharge would amount to 115 × 0.01228 ÷ 70 = 0.02017 lb. of steam per second, or 0.02017 × 60 × 60 = 72.6 lb. per hour.

Resistance in Series with Storage Battery—A battery made up of 16 cells requires a charging current of 25 amperes. What value of resistance must be connected in series with the battery to charge it on a 110-volt circuit. B. W.

Neglecting the internal resistance of the cells, which is very low, the external resistance $R = \frac{E-e}{I}$ where E is the charging circuit voltage, e the voltage required by the battery at the beginning of charging (normally 2 volts per cell) and I the charging current. At the beginning of the charge in this problem, e will equal about 2 × 16 = 32 volts. Therefore the external resistance $R = \frac{110-32}{25} =$ 3.12 ohms. If it is desired at any time to charge the battery at less than 25 amperes the external resistance will have to be increased in inverse proportion to the current.

Proximate and Ultimate Analysis of Coal—What is the difference between proximate analysis and ultimate analysis of coal? W. N. S.

The proximate analysis assumes coal to contain four different and separate ingredients called fixed carbon; volatile hydrocarbon or volatile matter or simply volatile; moisture; and ash. The percent of moisture is determined by maintaining a small quantity of finely ground coal at a temperature of about 200 deg. F. The material lost in this manner is assumed to be moisture and is reported as such. Volatile matter is determined by heating a sample from which the moisture has been driven or a fresh sample, for which purpose the coal is held at a red to white heat, with exclusion of air until there is no further loss of weight. Fixed carbon is found by combustion of a sample from which the moisture and volatile have been driven off; and ash is the designation of the incombustible material left after determining the fixed carbon. The sum of the volatile, hydrocarbons, and fixed carbon is called the combustible. When sulphur is to be reported it must be determined by a separate analysis. The ultimate analysis is a thorough chemical analysis for determination of the percentages of carbon, hydrogen, oxygen, nitrogen and sulphur and the percentage of ash in dry coal.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

The Willans Line*

By Alexander Jude

In the early days of the so-called high-speed engine it was shown by the late Mr. P. Willans that the total steam consumption of a throttle-governed engine plotted against load was a straight line. This characteristic line is known as the Willans Line. Moreover, the Willans Line is straight whether the load be plotted on a brake-horsepower basis or on a kilowatt basis, the generator losses also following practically a straight-line law. Obviously, by running a no-load test on an engine and one test at any selected load, and then drawing the Willans Line through the two points thus determined, we have the necessary data to compute or predict the steam consumption at any load.

This characteristic has been proved to hold also for all throttle-governed turbines, and its application to the problems of turbine design is pointed out in this article.

The multiple valve type of governing is applicable only to impulse turbines and is practically serviceable only in those turbines having a Curtis or a compounded velocity wheel for the first stage. Briefly, in these designs the full nozzle arc is cut up into fractions, each fraction being served by a separate and comparatively small throttle valve, so that the full steam-chest pressure is nearly maintained at all loads above that corresponding to the first fraction, the idea being that the full available head of steam shall be employed as much as possible. Now, the no-load consumption is practically the same, whether there be any number of nozzle valves or none at all. The reason is that the first stage blade system works at its lowest efficiency, which is very bad in any case, and, the bulk of the other stages doing negative work, there is little to choose between one bad condition and another. Further, all consumptions have a common origin at no-load no-speed. It has been the custom to state that the total consumption line in this case is a curve convex downward. This statement is not correct, but the true consumption line consists of a series of Willans Lines, there being a step-up at each valve opening, as indicated in Fig. 1. It is obvious that at any load throttle governing alone is taking place, and if, say, three nozzle valves are then open and kept open under governor control down to no-load, or rather beyond no-load to the point of being quite shut, the line would be *a b c d*, as shown in Fig. 1.

The steps shown in the heavier line are those caused by successive openings of the throttle valves as the load increased. At the initial opening of any valve the nozzle stream is too weak to operate efficiently, and it is not until the pressure immediately behind the blade rises sufficiently to produce a workable head that the incoming nozzle arc is of any service. There is, therefore, an inefficient step in the proceedings visualized by a step in the Willans chart. This step obviously is not vertical, but curved to the right and merging into the straight Willans Line as shown.

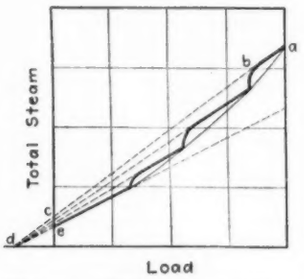


FIG. 1. WILLANS LINES FOR MULTIPLE-VALVE GOVERNED TURBINE

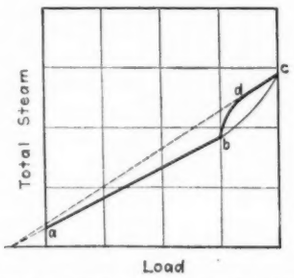


FIG. 2. WILLANS LINES FOR TURBINE WITH BY-PASS OVERLOAD VALVE

The same remarks apply to a bypass overload on any turbine. The consumption line extended to bypass overload is therefore not the conventionally assumed curve *a b c* in Fig. 2, but the curve *a b d c*.

*Abstract of an article in the May 28 issue of *The Engineer*.

In connection with bleeder turbines when no steam is being bled, the steam consumption will obviously be higher than that of an ordinary turbine because of the increased high-pressure disc and blade friction. In Fig. 3 the point *A* represents the consumption of an ordinary turbine at a given load, while a point *A'* will represent that for a bleeder turbine. The Willans Line for a bleeder turbine may then be represented by the line *A' B'*. This line should be continued to the no-speed no-load point at *X'*. Under the conditions that all the steam is taken out at the bleeder connection, the distance *XC* represents the steam consumption at the load *X* and the line *CEX'* is the Willans Line for the machine running under conditions that require all the steam to be bled. Suppose, now, that at the load *X* one-half of the steam is bled out; then one-half does the work under the conditions represented by *XA'* and the other half according to the difference between *XA'* and *XC*, so that the starting point is at *D*, halfway between *A* line and *C*. If the quantity of steam bled remains constant for partial loads, then, by the Willans law, the line through *D* must intersect the line *CX'* at *N*, so that *PN* equals one-half of *XC*. From the geometry of the case it follows that *DN* is parallel to *A'B* and *DN* is the Willans Line for the bleeder condition that an amount *XR* passes out at any load down to *P*. Below that point, of course, the required quantity cannot be passed out and the heating mains must be supplied from some other source.

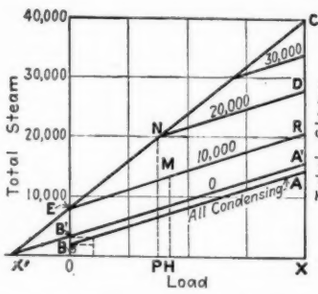


FIG. 3. WILLANS LINES FOR BLEEDER TURBINE

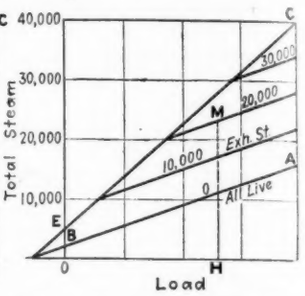


FIG. 4. WILLANS LINES FOR MIXED PRESSURE TURBINE

The chart for mixed-pressure turbines is similar to that for a bleeder turbine. In Fig. 4, *CE* is the Willans Line for all exhaust steam and *AB* that for all live steam. For any given amount of available exhaust steam the various Willans Lines are, as shown, parallel to the line *AB* for all live steam. For example, in the chart if 20,000 lb. of exhaust steam is available, the steam consumption at the load *X* would be about 28,000 lb., requiring about 8,000 lb. of live steam. At fractional load, say at load *H*, with 20,000 lb. of exhaust steam available, the total steam requirements would be as represented by *HM*, or 23,000 lb., and the live steam requirement is 3,000 lb.

The investigation of steam hose, described in a paper by John M. Bierer at the annual meeting of the American Society of Heating and Testing Materials, has for its object a determination of the relative values of seamless tubes compared with multiple-plied tubes, and the relative values of simple plied duck compared with a construction of fewer plies of duck supplemented by plies of braiding. Experimentally, these relations were determined by testing under steam pressure until failure, hose in which all elements were constant in the particular test, except those of which the relative values were to be determined. From the tests, it is concluded: (1) That a steam hose with seamless tube is superior in endurance to a hose with tube built up in plies. This is due to a splitting and separation at the joint necessarily formed in the construction of a plied tube. (2) That a steam hose with its fabric element a simple duck of several sufficient plies is superior in endurance to, and practically as good in contraction and expansion as, a hose made of less plies of duck supplemented by plies of braiding.

Better Utilization of Sub-Bituminous and Lignite Coals*

By S. M. Darling
Fuel Engineer, United States Bureau of Mines

The Nation's coal resources of all ranks total 3,553,637,100,000 minable tons of 2,000 lb., 1,051,290,000,000 tons, or nearly one-third, being lignite. Of this lignite 964,424,000,000 tons is in North and South Dakota and northeastern Montana, approximately 23,000,000,000 tons in Texas, 7,404,300,000 tons in Alaska, and relatively smaller quantities in several of the other Western and Southern states. The lignite tonnage given includes only group 3 (true lignite); it does not include group 2 (sub-bituminous coal), which in earlier days was called "black lignite" and classed with group 3.

TABLE I. AVERAGE PROXIMATE ANALYSIS OF LIGNITE

	Arkansas	Texas	N. Dak.
Moisture, per cent	29.73	28.63	27.13
Volatile hydrocarbons, per cent	37.87	32.53	29.11
Fixed carbon, per cent	23.95	30.43	36.16
Ash, per cent	8.45	8.41	7.60

The Alaska lignite closely resembles that of Texas and North Dakota. The sulphur content of the lignite in these fields rarely exceeds 1 per cent. The average heating value is about 7,500 B.t.u. per pound.

To burn high-volatile coals on furnace grates is wasteful. For many years leading engineers and chemists have decried the waste of burning bituminous coal raw; they have time and again shown that it is far more economical to break up the coal by means of carbonization, into its constituents—solid carbon, gas, ammonia, oils and tars—thus releasing these valuable products for use in their appropriate fields.

Instead of trying to burn the raw lignite in the primitive and wasteful ways now employed, the lignite should be treated so as to yield several products, each peculiarly adapted to a particular commercial need, as follows:

Dried lignite, for use on automatic stokers and in fuel-gas producers. Because of its more or less soft and comminuted condition, the dried lignite cannot be handled advantageously by hand, but it can be used satisfactorily by mechanical means.

Powdered fuel, from the dried, pulverized lignite, for use in cement kilns, under locomotive boilers, and in other large furnaces. Because of its high-volatile content this pulverized lignite makes an exceptionally good powdered fuel. The pulverized lignite can be used also in fuel-oil burners in conjunction with fuel oil. An oil mixture containing 30 per cent dried and finely pulverized lignite will still act as a fluid and can be burned as a liquid fuel. This would not only conserve petroleum resources, but would effect a saving in the cost of raising steam.

Dried lignite briquets, for large hand-fired industrial furnaces and heating plants. Where it is necessary to handle the dried lignite with a fireman's shovel, it should be briquetted. Tests of these dried lignite briquets in commercial boiler furnaces have proved them to be equal to good Middle West bituminous coal. An admixture of about 12 per cent of coking coal in the briquet is essential to hold the briquet together in the furnace.

Sulphate of ammonia and producer gas. The raw lignite, just as mined, when consumed in byproduct gas producers of the Mond type, yields sulphate of ammonia, producer gas, and some tars of undetermined value; there is no solid residue except ash. On the average, lignite carries about 1.40 per cent nitrogen. If this nitrogen were commercially recovered as sulphate of ammonia the yield would be about 70 to 80 lb. per ton of lignite. The gas yield per ton of lignite would be 60,000 to 70,000 cu.ft. of about 140 B.t.u. per cu.ft. This gas could be used as a furnace fuel or in a gas engine to produce power. If used in the latter manner, it would yield 700 to 800 hp.hr. per ton of lignite gasified.

The large way to utilize lignite is to carbonize it; that is, break it up into its four main divisions of gas, oils and tars, ammonia, and solid residue, the latter being practically charcoal. The fact that the lignite does not coke in the sense that bituminous coal cokes, but rather crumbles, on being carbonized, makes possible a continuous and comparatively inexpensive carbonizing process. Moreover, lignite parts with its volatile content more readily than does bituminous coal. And it is not necessary to subject the lignite to the high temperature required to produce commercial coke from coal. The gas is practically all driven off from the coking coal while the charge is still a black, intumescent mass, but it is necessary to carry the temperature several hundred degrees higher to procure a firm, hard coke. This increase in temperature is not necessary or desirable with the lignite. The entire process is mechanical; the fuel need not be handled by manual labor from the time the lignite is loaded into the mine car until the briquets are en route to the consumer. The costly element of labor is reduced practically to that required for directing mechanical operations.

TABLE II. THE PRODUCTS OF CARBONIZATION OF LIGNITE

Gas, per ton of lignite, cu.ft	10,000
Oil and tar, gal	15
Ammoniacal liquor, gal	65
Carbon residue, lb	955

Lignite vs. Coal Gas

	Lignite Gas	Coal Gas
Carbon dioxide	15.9	1.34
Illuminants	3.5	4.42
Oxygen	0.2	0.03
Carbon monoxide	19.5	6.75
Menthane	16.1	34.60
Hydrogen	43.9	59.19
Nitrogen	0.9	2.67
Candlepower	3.2	16.00
B.t.u. per cubic foot	440.0	630.00

A little more than one-half of the gas is necessary to carry on the carbonizing process; the balance can be used as a city gas for cooking, or for lighting if burned in a mantle, or for furnace fuel, or for generating power by means of a gas engine. Or, if desired, the entire 10,000 cu.ft. can be devoted to these purposes, and the carbonizing carried on with lignite producer gas from a fuel-gas producer.

As to power obtainable, of the yield of 10,000 cu.ft. per ton of lignite carbonized, 6,000 cu.ft. are required to carry on the process, leaving a surplus, costing nothing, of 4,000 cu.ft., of 400 B.t.u. per cu.ft., or a total of 1,600,000 B.t.u. A good gas engine uses about 10,000 B.t.u. per horsepower-hour, hence the surplus gas from each ton of lignite carbonized would yield 160 hp.hr. This power is comparable in cost with that derived from natural gas and is fully as cheap as most hydro-electric power.

Oil and Tar Products

Profitable disposition in this country for the oil and tar products remains to be determined. The simple distillation products of the oil can be put to many uses, such as fuel oil for furnaces and internal-combustion engines, gas enriching, flotation and other oils.

From the several fractions, by exhaustive distillation and treatment, there may be derived hundreds of synthetic products in the way of paraffine, acids, antiseptics, photographic chemicals, aniline dyes, perfume, drugs, preservatives, etc.

Light hydrocarbon oils of the class including benzol make a serviceable motor fuel, and their effectiveness is somewhat increased when mixed with gasoline; the light oils from lignite can be used economically in this way and thus in a measure eke out the failing supply of gasoline. The indications are that the consumption of motor fuel within the next decade will be double the present gasoline production. In many quarters alcohol is looked upon as one of the ultimate sources, if not the main source, of motor fuel. Commercial alcohol and gasoline are not readily miscible; alcohol and benzol are; and, after the benzol is added to the alcohol, the mixture will take up a high percentage of gasoline. It may be well that a large use for the benzol production will serve as the connecting link between gasoline and alcohol, aiding in the introduction of alcohol as a staple market commodity.

The ammonia is contained in the gas and gas water; it may be recovered as ammonium sulphate—a valuable fertilizer—as anhydrous ammonia, for refrigeration and other commercial purposes, or it may be treated as a source

*Abstract of paper read before the International Railway Fuel Association, Chicago, May, 1920.

of ether nitrogen products, some of which are of vital importance in the manufacture of explosives. For the production of power carbonized lignite is fully equal to anthracite, charcoal, or bituminous coke, the standard fuels for such purposes. This carbonized lignite can also be burned satisfactorily on the automatic stokers and grates used to consume the smaller sizes of anthracite.

Raw lignite is not serviceable in a locomotive firebox, and it is doubtful whether any form of lignite briquets can be manufactured cheaply enough to compete as a locomotive fuel with the bituminous and sub-bituminous coals now in use. The dried, pulverized lignite can be so used.

Chemical Industries to Play Part in Superpower Scheme

While it is recognized that the railroads must afford the principal market for electric current which may be developed if the Boston-Washington superpower plan should become a reality, it is recognized by those in charge of the superpower survey that the chemical industries will play fully as important a part in the scheme. This is due to the fact that the matter of locating central plants will depend on whether or not they are to be coupled with byproduct plants. The general impression has been that the big power plants would be located at the mine mouth, but if the byproducts of the coal are to be utilized, it is evident that the plant must be near the market for the byproducts. The chemical industries also are being relied upon largely to equalize the load factor. While these industries are large consumers of current, it is believed that they can arrange to take their maximum requirements at night and their minimum requirements during the hours of peak loads.

The survey will take into consideration the possibilities of developing nitrogen fixation. The possibilities of attracting electric smelting and refining industries and other power-consuming activities, including the heating of glass, will be given careful and prompt consideration.

An interesting incident of beginning the study of the load factor is the fact that the peak load in New York City for the week is on Tuesday morning, when the principal portion of the week's ironing is done.

Government Coal Inspection

Government inspection of coal came a step nearer realization recently when the Sewells Point Tidewater Coal Exchange entered into negotiations with the Bureau of Mines for just the sort of classification of coal on a scientific basis as was in mind when the fuel inspection bill was drafted. That bill never was introduced, due largely to the hostility of coal producers. Apparently there is a trend among producers to accept the contention that the proper classification of coal is a producer's problem. It is admitted that the glaring weak point in the war-time Tidewater Coal Exchange was the lack of a thorough coal classification. This depends on inspection and analysis. When iron ore sold for less than the present price of coal there was absolutely no thought of selling it without its having been analyzed. Coal producers are beginning to see, it is believed, that they have a valuable commodity which should be sold on the basis of an analysis.

Oil Engine Installations

A misconception exists among engineers as to the total amount of oil engine installations in the United States. The figures given below closely approximate the total horsepower installed; the errors are slight and are due to lack of data from two or three minor manufacturers. Motorship installations are not included.

Diesel Oil Engines	255,000 horsepower
Surface-Ignition Oil Engine	752,300 " "

Of the Diesels at least 10 per cent have been replaced by more modern engines. While no data is available in respect to the surface-ignition plants which have been replaced or discarded, probably 10 per cent of them are no longer in use. If the average fuel consumption is 7½ horsepower-hours per gallon of fuel, the yearly requirements would total 20,000,000 barrels of fuel. In view of the enormous consumption of gasolene in the automobile industry, it is apparent that the oil engine demand plays but a small part in the oil industry.

British Regulating Coal Export

The amount of coal being exported from British ports is being regulated by the Government to the last pound. The British exports for March and April of this year compared with 1913 were as follows:

	1913	1920
March	5,598,775	2,406,151
April	5,929,947	2,139,261

That there is a vast difference between the policy of the British Government and ours can be seen from the fact that America's coal is being offered by British operators and factors all over the world.

Rodding of concrete consists in repeatedly pushing a pointed rod into the concrete. This has the effect of expelling the entrapped air and excess water and of compacting the concrete. In so doing, the strength of the concrete is materially increased. The beneficial effect of rodding was noted in a number of experiments made in 1917 by G. A. Parkinson, assistant testing engineer, University of Texas. Since then, other tests have been made which demonstrate further the advantages of rodding concrete. Three series of these tests are described in a paper, by F. E. Giesecke, presented at the annual meeting of the American Society of Heating and Testing Materials. The first series is intended to show the general effect of rodding. The second series of tests is an investigation into the effect of the number of and the interval between roddings. In the third series concretes of different cement content are investigated, to determine the relative effect of rodding on each. In all the tests it is conclusively demonstrated that rodding substantially increases the strength of concrete. In many cases this increase is more than 100 per cent. It is therefore seen that rodding has an important bearing on actual construction, either by increasing the strength of the concrete or by effecting a saving in cement.

Geological Survey figures show a total bituminous-coal production of 10,225,000 net tons during the week ending July 3; 305,000 tons less than the preceding week. Production during the first 158 working days of the last four years has been as follows: 1917, 278,000,000 tons; 1918, 288,000,000 tons; 1919, 218,097,000 tons; and 1920, 262,727,000 tons. The year 1920 is thus 15¾ million tons behind 1917 and 26¾ million tons behind 1918, but is over 40 million tons ahead of 1919. Production of coal in the United States for the first six months of the present year is estimated by the Geological Survey as follows: January—Anthracite, 7,366,000 tons; bituminous, 48,698,000 tons. February—Anthracite, 6,335,000 tons; bituminous, 40,127,000 tons. March—Anthracite, 7,240,000 tons; bituminous, 46,792,000 tons. April—Anthracite, 6,543,000 tons; bituminous, 37,939,000 tons. May—Anthracite, 7,745,000 tons; bituminous, 39,753,000 tons. June—Anthracite, 7,641,000 tons; bituminous, 43,710,000 tons.

Reports to the Interstate Commerce Commission and to the Car Service Commission indicate that there has been a very decided improvement in car supply at all mines from Illinois eastward. On many railroads, all records for daily loadings have been broken. Better dumpings are reported at lower Lake ports. Even the Pennsylvania Railroad, after having piled up a deficit of more than 5,000 cars, is now meeting its late obligations. In order to do this, the Pennsylvania lines have had to embargo considerable other business and have had to eliminate the return loading of coal cars in many instances.

An estimate made for the National Coal Association places at $200,000,000 the additional freight which will be paid on coal, as the result of the railroad rate increase.

Society Affairs

The Pennsylvania Electric Association has arranged to hold its annual convention at Bedford Springs, September 8-11 inclusive.

The Michigan Section, N. E. L. A., will hold its convention at Ottawa Beach, Mich., Aug. 24-26. Papers and addresses on many subjects of interest to the public utility industry will be delivered.

The Cleveland Engineering Society will make its mid-summer trip to Detroit Friday, August 27-29. Members making the trip will be the guests of the Detroit Engineering Society on August 28. Visits will be made to the Ford Blast Furnace Plant and the Ford Motor Co.

The Executive Committee of the Southeastern Geographic Division of the N. E. L. A., which comprises the states of Alabama, Florida, Georgia, North Carolina, South Carolina, Tennessee and Porto Rico, has voted to hold its 1920 Convention at Miami, Fla., on Nov. 17 to 19 inclusive.

The New England Division of the National Electric Light Association will hold its twelfth annual convention at Mount Kineo House, Kineo, Me., Sept. 13 to 16 inclusive. An interesting program to include sports and dancing has been arranged and a number of important papers will be read.

The Northwest Electric Light & Power Association will meet at Spokane, Washington, Sept. 8 to 11. Franklin T. Griffith of the Portland Railway Light & Power Co. will address the meeting on the subject of "Successful Public Utility management of the Future." Other interesting papers will follow and the reports of various committees will be read.

The Nebraska Section of the National Electric Light Association has arranged to hold its annual convention in Omaha, Sept. 8 and 9 at which time reports of the activities of the section during the past year will be read and action taken that will result in the Nebraska Section becoming a part of the Middle West Geographic Division of the N. E. L. A. This Division will consist of the states of Iowa, Missouri, Kansas and Nebraska.

The Public Relations section of the N. E. L. A. appointed committees dealing with all phases of public relations at the second meeting of the Executive Committee at Toledo, Ohio, Thursday, Aug. 19. The full program of the Section was outlined and discussed, particular attention being given to the publicity program already tentatively arranged, and which will begin immediately following the meeting.

The American Peat Society will hold its thirteenth annual meeting at Madison, Wis., Thursday, Friday and Saturday, Sept. 2 to 4. Headquarters will be at the Park Hotel where special rates to members have been obtained by the entertaining committee. Papers will be read and excursions have been planned to give members the opportunity of observing growing crops on peat lands in the vicinity of Madison.

The 1920 Annual Meeting of the The Americn Society of Mechanical Engineers will be held in the Engineering Societies Building, 29 West 39th Street, New York City, from December 7th through to December 10. Sessions will be held on the subjects of Appraisal and Valuation and the Application of Engineering to Woodworking. The newly founded professional sections on Management Power, Fuels, Machine Shop, Railroads and Textiles will also conduct sessions to consider the vital problems in their field. In addition a number of valuable papers will be presented at General Sessions. A memorial session for Dr. Brashear is planned, as a fitting tribute to his life and work.

The American Welding Society at a meeting of members of the welding trade in Chicago, held in the rooms of the Western Society of Engineers, on Tuesday evening, Aug. 3, organized a Chicago Section of the society. There were about seventy-five in attendance, representing many railroads terminating in Chicago, and also many of the larger local industries. The following officers and directors were elected: Chairman, M. B. Osburn; vice-chairman, O. T. Nelson; secretary-treasurer, L. B. Mackenzie. Directors, E. Wanamaker, H. B. Bently, Andrew Oliver, W. M. Brady, Harold Cook, W. A. Slack, K. R. Hare, J. M. Jardine, W. H. Bleecker, Jr., Oliver Mitchell, Walter L. Senhort, Don B. McCloud.

Meetings will be held on the second Tuesday of each month in the rooms of the Western Society of Engineers, and those interested in the subject of autogenous welding by all methods are invited to attend.

Personals

Lorin E. Imlay has been appointed division engineer in charge of the power transmission division of the super-power zone engineering staff.

W. H. Edmundson, chief engineer at the Old Colony Brewery, Fall River, Mass., for the last two years, and chief engineer of the U. S. S. "Philippine" during the war, has accepted a position with the New England Oil Refineries Co., of the same city, as mechanical superintendent.

Irving E. Moultrop, assistant superintendent of the constructional Bureau of the Boston Edison Electrical Illuminating Co. has been elected as a member of the Engineering Foundation Board by Engineering Council to succeed the late E. Gybbon Spilsbury.

George M. Bassford, president of the Locomotive Feed Water Heater Co., New York, and formerly a member of the American Society of Mechanical Engineers Council has been elected a trustee of the A. S. M. E to succeed the late E. Gybbon Spilsbury to serve the unexpired portion of the term ending January, 1923.

New Construction

PROPOSED WORK

N. H., Portsmouth—The Bureau of Yards & Docks, Navy Dept., Wash., D. C., received bids for removing and reconstructing 2 boilers with stokers and stoker engine at the Navy Yard here from Frank Eisinger, 141 7th Ave., Brooklyn, New York City, $26,553; Shevlin Engr. Co., 110 West 34th St., New York City, $64,758.

Mass., Attleboro—William R. Walker & Son, Archts., 17 Custom House St., will soon award the contract for a 4 story, 95 x 140 ft. bank and office building including a steam heating system on Park St. for the 1st Natl. Bank.

Mass., South Byfield—The Dummer Academy plans to construct a central heating plant, etc. About $250,000. Noted July 20.

Conn., Windsor—The School Comn. will receive bids until September 7 for a 2 story, 90 x 155 ft. high school including a steam heating system. About $200,000. S. Brown, Chn. Whiton & McMahon, 36 Pearl St., Hartford, Archts.

N. Y., Great Neck, L. I.—The Bd. Educ. will soon receive bids for two 2 story schools including steam heating systems. About $400,000. F. Dickerson, Pres. W. S. Bessell, 56 West 45th St., New York City, Archt. and Engr.

N. Y., New York—The New York Edison Co., Irving Pl. and 15th St., is having plans prepared for a transformer station on 75th St. About $500,000. W. Whitehill, 12 Elm St., Archt. and Engr.

N. Y., New York—The Wendel Estate, c/o R. D. W. Swopl, 175 B'way, is having plans prepared for a 6 story loft and office building including a steam heating system at 444 5th Ave. About $500,000. John B. Snooks & Sons, 261 B'way, Archts. and Engrs.

N. J., Homestead (West Hoboken P. O.)—Andrews, Tower & LaValee, Archts. and Engrs., 33 Lyman St., Springfield, Mass., will soon award the contract for a 5 story, 85 x 205 ft. factory including a steam heating system for the Amer. Chocolate Products Co., 206 B'way, New York City. About $350,000.

Pa., Bellevue (Pittsburgh P. O.) — The School Dist. will receive bids until August 30 for two 25 hp., 1,200 r.p.m., 3 phase, 60 cycle, 220 volt slip ring motors with variable speed controller, bed plates and pulleys. Address James W. Graham, 545 Teece Ave., Secy.

Pa., Philadelphia—The American Coal & Ice Co., c/o Isaac Stevens, 4651 Paul St., is in the market for machinery for the manufacture of ice.

Md., Baltimore—The Bd. of Awards, c/o City Register, will soon award the contract for furnishing and installing new cast-iron, hot water, sectional manifold water tube boiler, etc., in the palm house here. W. F. Courts, Madison Ave., Park Engr.

Md., Orangeville (Baltimore P. O.)—The Columbia Graphophone Co., Woolworth Bldg., New York City, plans to install a 7,000 hp. generator at its plant here. Noted March 30.

Va., Portsmouth — Irving D. Ireland, Archt. and Engr., will receive bids until August 25 for a 30-ton ice-making plant and a 50-ton cold storge plant. Owner's name withheld.

Va., Richmond—The Colonial Pressing & Cleaning Co., 1639 West Broad St., is in the market for one new or used steam pressing machine, Hoffman preferred. L. S. Chatman, Mgr.

Va., Richmond—The Mullin Motor Garage Co., 436 West Main St., is in the market for an electric motor. L. A. McMullin, Mgr.

Va., Richmond—Stebbing & Paulie, 1643 East Broad St., is in the market for electric motor, vises and air compressor. New or used.

Miss., Tunico—The city will receive bids until September 8 for a 100,000 gal. reservoir, triplex pumping unit and pump house including a 380 g.p.m. triplex pump and crude oil engine. About $15,000. A. L. Dabney, Randolph Bldg., Memphis, Tenn., Engr.

Tenn., Sweetwater—The Durex Chemical Corp. is in the market for 400 hp. additional boilers. H. B. Gilman, Mgr.

O., Cleveland—J. A. Wetmore, Supervising Archt., Treasury Dept., Wash., D. C., will soon award the contract for furnishing and installing one new horizontal tubular return high pressure boiler at the U. S. Marine Hospital, East 9th St. and Lakeside Ave., here.

Ind., Richmond—The Wayne Co. Memorial Comn. is having plans prepared for a 4 story, 150 x 250 ft. memorial building including a low pressure heating system, etc. About $600,000. Study & Farrar, Arcade Bldg., St. Louis, Mo., Archts.

Mich., Detroit—Baxter, O'Dell & Halpin, Archts., 1024 Hammond Bldg., will soon award the contract for a 1 story, 65 x 100 ft. factory including steam heating equipment for the Amer. Machine Products Co., 18th and Howard Sts. About $45,000.

Mich., Detroit—The Detroit Council 305 Knights of Columbus Bldg. Co., 930 Woodward Ave., plans to build a 3 story clubhouse including steam heating equipment. About $500,000.

Mich., Detroit — The Natl. Alloys Co., Woodbridge St., plans to build a 1 story, 60 x 100 ft. foundry including an electric motor for power, etc. About $25,000. Horace H. Lane, Dime Bank Bldg., Engr.

Mich., Sunfield—The village plans to vote on a $15,000 bond issue for an electric light plant including equipment. W. R. Clark, Albion, Engr.

Ill., Harvey—The Whiting Fdry Equipment Co. plans to build a boiler room and is in the market for 2 new 506 hp. boilers. A. J. Haines, Asst. Supt.

Wis., Hartford—The Bd. Educ. plans to build a 4 story, 130 x 300 ft. junior high school including a steam heating system. About $500,000. Judge Sawyer, Chn.

Wis., Peshtigo—The Oconto Service Co. is having plans prepared for a 26 x 29 ft. addition to the power house. T. A. Pemperin, Pres. Mead & Seastone, Madison, Engrs.

Ia., Mason City—The Masonic Cathedral Association plans to build a masonic temple including a steam heating system. About $250,000.

Ia., Vinton—The city voted $45,000 bonds to build additions to the waterworks and

electric light and power plant. A new engine and generator will be installed in same.

Minn., Cannon Falls—The Cannon Falls Milling Co. plans to build a dam to furnish power for its use along the Cannon River here. E. O. Holmsted, 822 Flour Exch., Minneapolis, Mgr.

Kan., Bonner Springs—The Bonner Portland Cement Co., 200 Victor Bldg., Kansas City, Mo., plans to install transformers in its station here. P. R. Ladd, Chief Electrician.

Kan., Salina—The Wesleyan University is having plans prepared for a college building. Plans include an addition to the power plant. About $400,000. Study & Farrar, Arcade Bldg., St. Louis, Mo., Archts.

Neb., Atkinson—The City Clerk will receive bids until August 28 for a power house, etc., in connection with the proposed waterworks improvements. About $25,000. W. E. Standeven, 616 Peters Trust Bldg., Engr.

S. D., Volga—The city had plans prepared for an electric light plant.

N. D., Grand Forks—The North Dakota Industrial Comn. will receive bids until August 30 for installing piping and all auxiliary equipment in power plant at terminal elevator here. C. A. Pillsbury Co., 805 Metropolitan Life Bldg., Minneapolis, Minn., Engr.

N. D., Minnewaukan—The village will received bids until September 8 for the installation of an electric light plant.

Mo., Carthage — The city sold $100,000 bonds to enlarge the water and electric light plant. John N. Marsh, Treas.

Mo., St. Joseph—The Western Tablet Co., 11th and Mitchell Sts., will receive bids about September 15 for a power house. About $35,000. R. and E. R. Meier, 203 Lincoln Bldg., Archts.

Okla., McAlester—The Abbort Pike Lodge is having plans prepared for a 5 story Masonic temple including a steam heating system. About $500,000. Thompson & Harding, 504 Southern Trust St., Little Rock, Ark., Archts.

Okla., Oklahoma City — The Missouri, Kansas & Texas Ry. of Texas and the Wichita Falls & Northwestern Ry., Ry. Exch. Bldg., St. Louis, Mo., plans to build several buildings including a machine shop and power plant, etc. F. Ringer, Chief Engr.

Okla., Tulsa—The 1st Methodist Episcopal Church will soon receive bids for a church including a steam heating system. About $250,000. Wight & Wight, 400 1st Natl. Bank Bldg., Kansas City, Mo., Archts.

Okla., Tulsa — Thompson Bros. and Hughes will receive bids until September 1 for a 10 story, 100 x 200 ft. office building including a three boiler heating plant. About $750,000. Herbert L. Bass, 801 Hume Mansur, Indianapolis, Ind., Archt.

Cal., San Francisco—The Amer. Can Co., 120 B'way, New York City, is having plans prepared for a factory including a steam heating system. About $500,000.

Ont., Ford City—The Fisher Body Co. of Canada plans to build a 4 story, 90 x 192 ft. factory including a steam heating boiler, etc., on St. Lukes Rd. Albert Kahn, Walker Rd., Walkerville, Archt.

Ont., Owen Sound—The Lovat Brick & Tile Co., Lovat, plans to rebuild its plant which was recently destroyed by fire and is in the market for a boiler and engine, etc. About $20,000.

CONTRACTS AWARDED

Me., West Pownal—The Maine School for the Feeble Minded has awarded the contract for an extension to the heating plant to the Johns-Manville Co., 55 High St., Boston, Mass., and the Willy Calhoun Co., Portland, Me., at $25,000.

N. H., Nashua—The Nashua Mfg. Co. has awarded the contract for altering the boiler plant to the Nashua Bldg. Co., 95 Temple St., at $25,000.

Mass., Arlington — The Bd. Educ. has awarded the contract for the installation of a heating and ventilating system in the proposed junior high school here to the Ross, Chase Co., 263 Sumner St., Boston, at $27,958.

Mass., Cambridge—The City Hospital has awarded the contract for the installation of a steam heating system in the proposed 3 story, 77 x 140 ft. hospital on Cambridge St. to Lynch & Woodward, 287 Atlantic Ave., Boston, at $16,670.

Mass., Stoughton—The Panther Rubber Co., Suffolk St., Chelsea, will build a 2 story, 60 x 70 ft. manufacturing plant addition including a steam heating system on Monk St. About $350,000. Work will be done by day labor.

Mass., Taunton—The Municipal Lighting Comn. has awarded the contract for an addition and extensive improvements to the electric plant on West Water St. to the Westinghouse Electric Co., 6905 Susquehanna St., Pittsburgh, Pa., at $400,000. Noted July 20.

Mass., Quincy—The Bethlehem Shipbuilding Corp., Fore River, has awarded the contract for a 1 story, 22 x 35 ft. addition to its power house, etc., to the Aberthaw Constr. Co., 27 School St., Boston, at $75,000.

R. I., Phillipsdale—The Amer. Electrical Wks. has awarded the contract for a 1 story, 15 x 40 ft. transformer building to Bowerman Bros., 630 Grovenor Bldg., Providence.

N. Y., Brooklyn — The Kalman Constr. Co., 1779 Pitkin Ave., will build a 1 story, 100 x 150 ft. garage including a steam heating system on Avenue J. About $300,000. Work will be done by day labor.

N. Y., Brooklyn—The New York Edison Co., Irving Pl. and 15th St., will build a sub-station on Grand Ave. Work will be done by day labor.

N. Y., New York—The New York Edison Co., Irving Pl. and 15th St., will build a transformer station on the Bowery. Work will be done by day labor. Noted June 8.

N. Y., New York—The New York Edison Co., Irving Pl. and 15th St., will build a sub-station on Cedar St. Work will be done by day labor. Noted April 27.

N. Y., Yonkers — The Yonkers Electric Light & Power Co. has awarded the contract for the construction of a transformer station on Dunwoodie Ave. to Fitzpatrick & McArthur. Noted June 8.

N. J. Dover—The Construction Division War Dept., Wash., D. C., has awarded the contract for a small heating plant at the Picatinney Arsenal to Lustig & Weil, 10 Park Ave., New York City, at $42,300.

N. J., Newark — The Clark Thread Co., Clark and Ogden Sts., has awarded the contract for two factory buildings including a steam heating system to John W. Ferguson, United Bank Bldg., Paterson.

Va., Hampton Roads — The Bureau of Yards & Docks, Navy Dept., Wash., D. C., has awarded the contract for an electric underground distributing system at the Naval Operating Base here to John E. Proctor, 74 Cortlandt St., New York City, at $34,880. Noted March 30.

Ala., Florence—The United States Engineer's Office, War Dept., Wash., D. C., has awarded the contract for 4 generators, etc., for the Wilson Dam to the Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., at $779,400.

Ill., East St. Louis—Darling & Co., 4201 South Ashland Ave., Chicago, has awarded the contract for a fertilizer plant including a high pressure steam heating system to the Austin Co., 208 South La Salle St., Chicago, at $500,000.

Ill., Hillsboro—The Bd. Educ. has awarded the contract for a 2 story, 150 x 150 ft. high school including a low pressure heating system and power plant to Jesse Gedney, Arcade Bldg., St. Louis, Mo., at $201,214.

Ill., Melrose Park—The Heppes Nelson Roofing Co., 4500 Filmore St., has awarded the contract for a roofing manufacturing plant including a 1 story, 50 x 60 ft. boiler house, etc., to the Austin Co., 208 South La Salle St., Chicago, at $400,000.

Minn., Albert Lea—The city has awarded contract for 2 motor driven centrifugal pumps with automatic controls, 2 air compressors and 2 motors with belt drive, 1 horizontal driven double suction centrifugal pump, etc., to John W. Hildred & Co., 33 East 3d St., St. Paul, at $6,210. Noted June 29.

Minn., St. Paul—The Bd. Educ., City Hall, has awarded the contract for the installation of a steam heating system in the proposed 2 story, 60 x 128 ft. school on Hamline Ave. between Jefferson and Lansing Sts. to the Hankee Heating Co., 925 Merchants' Natl. Bank Bldg., at $14,814. Noted July 27.

Kan., Salina—The Masonic Temple Association has awarded the contract for a 5 story Masonic temple including a steam heating system to the Eberhardt Constr. Co. at $750,000.

Mo., Kansas City—The Kansas City Light & Power Co., 3rd and Lydia Sts. has awarded the contract for a 2 story, 46 x 57 ft. sub-station to the Fogel Constr. Co., 618 Reliance Bldg. Noted July 20.

Ore., Portland—The Amer. Can Co., 120 B'way, New York City, has awarded the contract for a factory including a steam heating system to A. W. Quist at $750,000.

NEED COMPETENT MEN?

SEE THE SEARCHLIGHT SECTION

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